# DELIVERING MORE THAN BOMBS:

# THE UTILITY OF LONG-RANGE STRIKE PLATFORMS

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The undersigned certify that this thesis meets master's-level standards of research, argumentation, and expression.

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The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

## ABOUT THE AUTHOR

Maj Scott Weyermuller was a distinguished graduate of the USAF Academy class of 1999, where he majored in Engineering Sciences and minored in Mathematics. Upon commissioning, he spent his first assignment earning a Master's of Aerospace Engineering in the Air Force Institute of Technology's Civilian Institute program at the University of Texas at Austin. He then worked for three years as an A-10 structural engineer and executive officer in the Mature and Proven Aircraft Directorate at the Ogden Air Logistics Center, Hill AFB, Utah. He attended Euro-NATO Joint-Jet Pilot Training at Sheppard AFB, Texas in 2004 and began his flying career piloting B-52H aircraft in the 20th Bomb Squadron at Barksdale AFB, Louisiana. In 2008, he was assigned to the 13th Bomb Squadron at Whiteman AFB, Missouri where he flew B-2A and T-38A aircraft. A senior pilot, he has accumulated over 1600 hours in jet aircraft and over 30 combat hours. In 2011, he became a student in the School of Advanced Air and Space Studies. His next assignment will be Chief of the Combined Force Plans Branch at US Army Garrison Yongsan, Korea.

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ABSTRACT

Heavy bombers have proven themselves as highly capable weapon systems since their introduction to the USAF in World War II. Rather than analyzing the different capabilities each iteration of bomber possessed over time, this study focuses on the functional characteristics long-range strike aircraft have contributed toward affecting their respective strategic environments. This study offers historical analyses of the B-17, B-52, and B-2 because these aircraft span the gamut of USAF long-range strike airpower. The B-17 became the first truly "strategic" bomber that enabled crews to attack targets at ranges inaccessible before its conception. The B-52 proved itself as the mainstay of nuclear delivery platforms during the Cold War and still fulfills conventional and nuclear roles today. Finally, B-2 designers produced a radically different platform based on survivability and stealth, capable of delivering multiple types of precision weapons against highly defended targets.

The three case studies concentrate on each bomber's functionality from development through major combat operations within the context of an evolving strategic environment. The thesis deduces the qualities expected of the future strategic environment spanning the next twenty years. Accordingly, long-range strike aircraft will play a major role within a landscape distinguished by further globalization, major power distribution, and rises of non-state actors. Within this landscape, adversaries will continue to seek asymmetric advantages over legacy US airpower capability.

This study concludes by inducing nine functional characteristics the next long-range strike bomber (LRS-B) should possess to maintain global US power projection. *Range*, *persistence*, *penetrant strike*, *flexibility*, *multi-payload*, *precision*, *deterrence, economy of force,* and *integration* will remain vital functionalities for the LRS-B. Without a timely investment to innovate and sustain these functional characteristics in the form of a new bomber, the US will jeopardize its ability to support its national defense policy and maintain its national interests abroad.

CONTENTS



Illustrations

Table

# Introduction

Underpinning the US air arsenal since World War II, long-range strike aircraft have fulfilled several important roles. Over time, technological breakthroughs have improved capabilities across the bomber fleet at the tactical and operational levels. However, understanding how the capabilities of long-range strike aircraft have contributed to warfare in the context of their respective strategic environments provides the foundation for compiling their enduring functional characteristics. These characteristics have accumulated throughout the history of military flight, and they provide significant insight to the relevance of heavy bombers in the strategic settings of today and tomorrow. As the USAF confronts how to proceed with its aging bomber fleet in a new landscape of advanced defenses and dynamic threats, this study will better inform the strategic decisions regarding a new bomber acquisition program.

## Research Question

This thesis provides chronological analyses of three heavy bombers by studying their distinct developmental and employment periods in USAF history. It answers a single question: What functional characteristics does a new long-range strike bomber (LRS-B) offer in the current and future strategic environment? Using history as a comparative lens, the author parses seven characteristics of heavy bombers that have prevailed despite technological innovation in addition to two characteristics that depend upon the evolution of military technology.

The author chose the following three case studies to illustrate the similarities and differences of fundamental functional characteristics across the gamut of US bomber aircraft. Historians and airmen alike

regard the B-17 as the first truly "strategic" bomber,[1] enabling crews to attack targets at ranges inaccessible before the technological leap from two- to four-engine aircraft. The B-52 proved itself as the backbone of nuclear delivery platforms during the Cold War. It maintains the longest service history of any US bomber and continues to fulfill a conventional and nuclear role today, 60 years after its inception. Finally, B-2 designers produced a radically different platform based on survivability and stealth, capable of delivering multiple weapon types against highly defended targets. These three platforms span the breadth of US heavy bomber history and encompass the realm of functional characteristics that strike platforms have delivered to the warfighter.

The features of the strategic environment in which the USAF developed and produced each bomber prove fundamental to their respective functional characteristics. As the bomber evolved, the number of characteristics long-range strike aircraft offered to US leadership increased and, when combined, directly relate to today's bomber force. The Department of Defense (DOD) and USAF have proclaimed interest in the development of a new stealth bomber in response to growing threats from anti-access and area denial (A2/AD) environments.[2] Because long-range strike capability offers deterrence, flexible response options, and contributes to the freedom of maneuver across the air domain, Air Force

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[1] Here the term "strategic bomber" denotes the contemporary understanding of employing attack aircraft to achieve effects against an enemy's war making capacity and will to wage war. In contrast, most strategic bomber advocates through World War II applied an expanded definition to strategic bombing to include the ability of bombers to obtain decisive, grand national objectives. In other words, most Allied airpower proponents believed aerial bombardment of Axis cities could win World War II without a ground invasion. Colin Gray best distinguished the misapplication of the term: "all weapons are tactical in their immediate effect, and all weapons are strategic in the consequences of their actions" in Colin S. Gray, *Explorations in Strategy* (New York: Praeger, 1998), 61. Strategic bombing does not include the characteristic of decisiveness for the purposes of this paper. Therefore, the author considers the terms strategic bomber, long-range strike platform, and heavy bomber synonymous and uses these terms interchangeably.

[2] Office of the Secretary of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Department of Defense, January 2012), 4-5.

leadership has recently prioritized funding toward the LRS-B effort.[3] The LRS-B presents an attractive solution because the USAF must maintain dominance in the long-range strike arena to project power, maintain regional stability, and protect US national interests in the future strategic environment.

## Limitations and Assumptions

The unclassified nature of this study limits its treatment of bomber capabilities. Details of programs like the B-2 and the requirements for the new LRS-B remain classified. These security limitations further restrain the technological descriptions used to describe the attributes of each bomber. The author, therefore, generalizes many specifics regarding technological capabilities. Furthermore, emerging technologies in other strike capabilities from non-bomber weapon systems are neither known nor available at an unclassified level to compare to the effectiveness and efficiency of the derived bomber functional characteristics in this study.

Because of these limitations, this thesis offers several assumptions. First, bomber functional characteristics, not capabilities, remain the primary and most useful method to derive a comparative analysis between LRS aircraft. Technological capabilities directly contribute to the functional characteristics derived throughout the study, but these capabilities are not the objects of comparison. Second, the functional characteristics prescribed for the LRS-B consider the platform as a single entity and not a combination of multiple weapon systems. While the final functional characteristic below realizes the importance of weapon system integration, this study does not offer a solution to how that integration should occur. Finally, this study assumes, based upon classification limits, the technological readiness levels for the new LRS-B

[3] *Air Force Priorities for a New Strategy with Constrained Budgets,* Office of the Chief of Staff of the Air Force (Washington D.C.: U.S. Air Force, Feb 2012) 4.

will produce a platform similar to the contemporary image and understanding of heavy bombers in terms of appearance and operation. This study has not researched radically new concepts. It relies on a fundamental premise to reinvigorate dominance in the LRS arena without a lengthy and costly acquisition program.

## Thesis Structure

This study is comprised of three historical bomber case studies, a strategic environment analysis, and a synthesis that provides recommendations for a future long-range platform. The case studies cover the B-17, B-52, and B-2 aircraft and discern the relevant strategic environments influencing each of these programs. Each case study chronologically delineates the phases of the bomber's development through production and then depicts how the USAF employed the bomber in combat operations. These chapters conclude by showing how each bomber contributed to a cumulative list of functional characteristics bombers provide to civil and military leadership alike. The fourth chapter defines the prominent strategic features of the current and projected globalized landscape pertinent to long-range strike capability, and the fifth chapter fuses the functional characteristics of past long-range strike aircraft with the future strategic environment. This study concludes the historical analyses of bomber functional characteristics, in concert with an understanding of the future strategic environment, provide a useful foundation for developing a new long-range bomber. Future applications of long-range strike airpower will continue to provide deterrence and essential kinetic capability in the future strategic environment.

# Chapter 1
## B-17 Flying Fortress Case Study

During the majority of the period between the two World Wars, American doctrine subjugated airpower to the requirements of army and naval forces. Airpower zealots argued for the development of airpower as a decisive war-winning tool through what they coined "strategic bombing," but their offensive approach initially found little traction during a period of American isolationism and scarce military resources available to develop theory into practice. Airpower proponents argued the only way to fulfill the true potential airpower could offer the warfighter was to produce massive bombers, capable of striking deep into enemy territory against military industrial targets and civilian population centers. Delivering kinetic effects against deep strategic nodes to affect the will of the population, well beyond the stagnant frontline trenches of World War I, offered combatant commanders a means to save countless lives and time. As the United States supplied the Allies with war materials and postured itself to enter World War II, proponents of strategic bombing gained influence against the emerging German threat. In September 1939, the Secretary of War declared a new role for American airpower focused on destroying the enemy's means of waging war and overcoming his will to resist.[1] Civil directive now released the Army Air Corps from strictly supporting fielded forces to a role providing direct strategic impact. The development and employment of the B-17 as the world's first strategic bomber illustrated functional characteristics of long-range strike aircraft critical to the strategic environment presented by World War II.

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[1] Richard J. Overy, "Strategic Bombarment before 1939: Doctrine, Planning, and Operations," in *Case Studies in Strategic Bombardment,* ed. R. Cargill Hall (U.S.: Air Force History and Museums Program, 1998) 34.

## B-17 Development

Amidst this debate concerning the strategic role of airpower, B-17 designers struggled with one of the first historical competitions within the aircraft industry to meet a new military requirement with a revolutionary air platform. Before strategic bombing doctrine took form in 1939, the Army Air Corps anticipated a need to explore its ideas for long-range military aircraft. The first recommendation for the Air Corps to develop four-engine heavy bombardment aircraft surfaced in 1933,[2] and, in July 1934, the Air Corps defined the specifications for the bomber it envisioned to replace the aging Martin B-10. The Air Corps required this next production bomber to carry a "2,000 lb bomb load at a speed of 200-250 mph over a distance of 1,020-2,000 miles."[3] Boeing submitted its four-engine Model 299 against the twin-engine Martin 146 and Douglas DB-1. Later coined the XB-17, Boeing's Model 299 outperformed the twin engine competition in speed, climb, and range by carefully limiting its size and 15 ton basic weight to match the engine technology available at the time.

The Air Corps ultimately desired a platform capable of maximal range. Because doctrine for offensive strategic bombardment had yet to take form, the Air Corps exploited the development of heavy bombers for homeland defense. Envisioned to attack naval forces approaching the shores and fly from the west coast to defend Hawaii and Alaska, the XB-17 gained favor when it surpassed the 2,000-mile design specification. Despite the Air Corp's defensive vision, the War Department did not share the same sentiments for bomber production in the mid to late 1930s. When General Craig took charge as the War Department Chief-

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[2] Overy, "Strategic Bombardment," 57.

[3] Bowman, Martin W., *Flying to Glory: The B-17 Flying Fortress in war and peace,* 1st ed. (Somerset, Great Britain: Patrick Stephens, 1992), 9. Another concurrent Air Corps request proposed a bomber capable of carrying a 2,000 lb payload 5,000 miles. Boeing responded with the 35 ton XB-15 design, never produced beyond a single prototype due to its thrust limitations and its slow, altitude-limited characteristics ill-suited for combat aircraft.

of-Staff from General MacArthur, the tides turned against long-range bombers. Craig wanted lighter bombers capable of supporting ground troops and deemed heavy bombers unjustified. Using the crash of a Model 299 during a test flight as a springboard, Craig persuaded the War Department to cancel its original procurement plans for 60 B-17s in 1937 and 1938 in favor of lighter twin-engine bombers. Despite Douglas' smaller, inferior aircraft, the War Department awarded the company a contract for 133 B-18s (BDB-1 production aircraft) in 1937 and ordered only 13 Y1B-17 test aircraft from Boeing.[4]

Although the War Department nearly scrapped the B-17 altogether, air proponents in the Army general staff endeavored to bring the B-17 to production as the pathway to strategic bombardment. If strategic bombardment gained enough momentum, its supporters would depend on it as the means for an independent Air Corps. Boeing even contributed to the cause. By naming the aircraft "Flying Fortress," for its multiple protruding machine gun turrets, the airplane assumed a misunderstood but primarily defensive connotation. In this light, the Air Corps formed its case before Congress and the War Department.[5] As the crisis in Munich in September 1938 propelled Europe closer to war, President Roosevelt sided with military and political circles favoring aerial bombardment and saved the B-17 program. He appointed an Air Board to examine military aircraft procurement in 1939, which pulled the debate away from the Army's focus on light bombers and directly led to accelerated B-17 production. As the B-17 started to gain momentum, the Air Corps pushed industry even further by providing specifications in 1940 for another large bomber capable of a 4,000-mile range.[6] Boeing,

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[4] Bowman, *Flying to Glory*, 11.
[5] Frederick A. Johnsen, *B-17 Flying Fortress: the Symbol of Second World War Air Power* (New York: McGraw-Hill Professional Publishing, 2000), 6-7.
[6] Overy, "Strategic Bombardment," 59. These specifications led to the production of the B-29 Superfortress, seen toward the end of the war, and later the B-36 Peacemaker aircraft. Both were capable of reaching Europe from the United States.

helped by Douglas and Vega to meet war demand, produced 12,731 B-17s by the end of the war, second only to the B-24 Liberator.[7]

## B-17 Employment

The B-17 fulfilled many roles throughout and after its service in World War II. During a period of isolationism when the War Department was not interested in spending tax dollars on offensive, technologically expensive military programs, developing a small fleet of heavy bombers with defensive capabilities offered a deterrent capability for Congress. As the situation in Europe grew volatile in 1939, the Air Corps still focused on "hemisphere defense and aid to Britian and France as its only clearly sanctioned strategic missions."[8] Searching to give the B-17 a place in the US arsenal, the Air Corps initially demarcated it as a defensive platform. In May 1939, three B-17s demonstrated their utility in a homeland defense role as they intercepted an Italian ocean liner and dropped a message on the ship's deck. This and other sea-interception exercises proved the Air Corps capable of locating enemy ships some 700 miles off the Atlantic coast and that aircraft could find and attack fleets threatening the coastlines quicker than the Navy could mobilize.[9]

Once World War II erupted and the Army Air Forces (AAF) took the B-17 to battle, the defensive nature of US air strategy all but disappeared. The proponents of long-range strategic bombing quickly gained support based on what the bomber promised, not on what its technology could yet deliver. With the rapid fall of France, they anticipated large bombers cable of striking deep into Germany much sooner than the army could train and field a massive ground force to retake the continent. This initial momentum among political and military circles set an early stage where the aircraft industry dedicated

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[7] Bowman, *Flying to Glory*, 210.
[8] Michael S. Sherry, *The Rise of American Air Power: The Creation of Armageddon* (New Haven, CT: Yale University Press, 1987), 90.
[9] Sherry, *Rise of American Air Power*, 61-62.

its resources to heavy bomber development. In contrast, the senior Joint Chiefs would have rather armed the AAF with lighter bombers capable of dive-bombing tactics and better equipped to support troops and the ground effort. The AAF did not fully oppose this role for air warfare, but rather chose to focus its initially limited industrial resources on an air capability that promised greater return as a decisive method of warfare and AAF independence. Boeing had already conducted five years of B-17 testing and development prior to the beginning of the war, and they proceeded into full production.

In contrast to lighter bombers, only the B-17 demonstrated a truly offensive capability at the start of the war to take the fight to the enemy. In addition to flying long distances to attack German targets located deep behind enemy lines, the B-17 also promised the means to attack Japanese island and naval targets from US strongholds in the Pacific. Despite the potential success for B-17s in an anti-maritime role, the quick arrival of the B-24 best accomplished this mission in both the Atlantic and Pacific theaters. Although it employed the same high-altitude level bombing tactics as the B-17, the B-24 offered even greater range, ceiling, speed, maneuverability, and payload; all helpful attributes against a maneuverable target set. Furthermore, B-17s delivered the first attacks on Japanese ships at the Battle of Midway, but they proved ineffective compared to the dive-bombing tactics of smaller aircraft like the B-25 Mitchell. B-17s also went on to perfect the tactic of skip-bombing, but their lack of maneuverability at the low altitudes required for this tactic left them vulnerable to anti-aircraft fire.[10] High altitude bombing of fixed targets hence replaced the B-17's US coastal defense mantra. In August 1942, the B-17 launched its first heavy bomber raid against the European continent with 12 bombers against a marshaling

[10] Thomas E. Griffith Jr, *MacArthur's Airman: General George C. Kenney and the War in the Southwest Pacific* (Lawrence, KS: Univ Pr of Kansas, 1998), 82.

yard at Rouen-Sotteville, France.[11] Initial daylight raids such as this demonstrated success, especially since heavy bombers provided the only means to strike German targets. The B-17 and its strategic bombardment doctrine, however, proved ill prepared to meet the growing air defenses of the Luftwaffe.

Conflicting early assessments of the B-17's success fostered debate between the Royal Air Force (RAF) and the AAF over the efficiency and efficacy of nighttime area bombing versus daylight precision bombing. Accurate and timely battle damage assessments remained difficult to achieve, often resulting in inflated results. At times, the RAF and AAF opted "to bomb badly rather than not at all"[12] in order to report large numbers of dropped tonnage rather than sorties returning with their weapons. As the overall impact of early strategic bombing missions showed little impact on German military industry and morale, the AAF chose to improve its precision delivery tactics while the RAF decided to proceed with nighttime area bombing. Sustaining heavy daytime losses, the RAF gave up pursuing precision to increase the chances of reaching its desired target areas.

As the war progressed, the use of navigation aids, pathfinder techniques, intersecting radio beams, rudimentary radar, and the Sperry and Norden bombsights increased targeting accuracy. Despite these improvements in finding targets, bomb technology available at the time often rendered minimal damage to targets, especially hardened targets such as submarine pens. Further, a drastic increase in German aerial defenses and Luftwaffe attacks on unescorted bomber formations increased the costs of long-range attack missions. The AAF required long-range escort fighters and stronger armament on its aircraft. Boeing improved the frontal defenses on later B-17 models by adding a

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[11] Stephen L. McFarland and Wesley Phillips Newton, "The American Strategic Air Offensive Against Germany in World War II," in *Case Studies in Strategic Bombardment,* ed. R. Cargill Hall (U.S.: Air Force History and Museums Program, 1998) 185.
[12] Sherry, *American Air Power,* 162.

mechanized turret versus the original manual gun. The AAF also attempted to fly several B-17s as escorts within the bomber formations to improve formation defense. These escorts replaced the weight of their bomb payload with extra guns and ammunition but still proved less effective than the speed and maneuverability offered by fighter aircraft. Tactical improvements, aircraft upgrades, and the AAF's effort to keep strategic bombing the top priority over other supporting roles significantly improved the results of long-range heavy bombing as the war of attrition progressed. Strategic bombing, however, did not deliver the decisive outcome its advocates originally desired.[13]

Notwithstanding the debate concerning the success of strategic bombing, competing theaters and mission sets illustrated the versatility of the B-17. The original defensive role took a slightly different form as the Navy demanded B-17 aerial support to attack submarine pens ultimately threatening Allied convoys in the Atlantic. In preparation for the mainland invasion, commanders interrupted long-range B-17 strikes against German cities and war economy with interdiction target sets such as communication nodes, airfields and rail yards.[14] The AAF also employed B-17s in non-attack roles to tow fighters from the mainland back to England for repairs. B-17s carried and dropped lifeboats and supplies to stranded crews and troops. They flew photo recon missions and provided DV transport for high-ranking military officers.[15] They also saw extensive use in North Africa, served as sector patrols to provide strategic warning over Guadalcanal, and even strafed lightly-defended Japanese positions in the Western Pacific.[16] After the war, the Air Force mechanized the flight controls and throttles with remotely controlled inputs and flew B-17 drones over Bikini atol to obtain radiation samples

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[13] Sherry, *American Air Power*, 165-166.
[14] Richard J. Overy, *The Air War*, 1939-1945 (Washington, D.C.: Potomac Books Inc., 2005), 75.
[15] Johnsen, *B-17 Flying Fortress,* 27-32.
[16] Johnsen, *B-17 Flying Fortress, 52-53.*

during nuclear tests. B-17s have seen extensive use as search and rescue platforms and to drop fire retardant out of its bomb bays to fight domestic forest fires. They also provided an excellent first-generation multi-engine training aircraft and test bed for engine development.[17]

## Conclusion

As the first truly strategic bomber, the B-17 provided several functional characteristics for the AAF. These functional characteristics proved fundamental within a strategic environment characterized by total war. *Range*, *persistence, penetrant strike,* and *flexibility* resonated through the B-17's service in World War II. First, Boeing mass-produced the first four-engine platform capable of flying *ranges* that made air attacks on central Europe from Great Britain possible. Compared to twin-engine aircraft, the B-17 also provided improved capabilities of speed, altitude, endurance, armament and payload. Combined with the large quantities of heavy bombers produced during the militarization of the industrial war effort, these five capabilities resulted in the second functional characteristic of *persistence*. The B-17 could fly for long periods over enemy territory, patrol over large sectors of airspace, and sustain moderate battle damage in the process. The B-17, however, could not achieve its tactical objectives autonomously. Despite its several machine gun turrets, the B-17 could not defend itself against the Luftwaffe's substantial fighter threat and reach its targets without significant long-range escorts. Fighter escorts coupled with massive quantities of bombers eventually enabled the B-17 to attack highly defended targets with moderate success as the war progressed. Therefore, despite German effort to expand its Luftwaffe and increase anti-aircraft fire around its industrial complexes, the B-17 demonstrated its third functional characteristic of *penetrant strike* based on its ability

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[17] Johnsen, *B-17 Flying Fortress,* 141-147.

to mass kinetic effects upon heavily defended target areas. The B-17 placed pressure upon German forces and its production capability throughout the war, especially during the initial stages when fielded armies could not yet counter the advancing German Blitzkrieg. As such, the AAF used the B-17 to take the offensive against Germany before any other means of attack became available. Finally, the B-17 proved itself a *flexible* air platform. While strategic bombing remained its primary role during World War II, the B-17 also fulfilled multiple supportive mission sets requiring both bombardment and non-kinetic functions. As will be seen in the next two case studies, these four features, summarized in Table 1, provided a baseline for long-range bombardment platforms in later strategic environments.

**Table 1: B-17 Functional Characteristics**

| Functional Characteristic | B-17 |
|---|---|
| Range | Strike European mainland from Great Britain |
| Persistence | Loiter over enemy territory & sustain moderate damage |
| Penetrant Strike | Massive formations coupled with fighter escorts |
| Flexibility | Fulfilled several combat and non-combat roles/missions |

*Source: Author's Original Work*

Chapter 2

B-52 Stratofortress Case Study

After World War II, the strategic environment began an era of rapid change. Instead of the peaceful period of military reduction typically following total war, the advent of the Cold War quickly pitted the US against the USSR in a nuclear arms race. Soviet nuclear weapon development became only a matter of time. Having secured Western and Central Europe for the Allies and having removed the existential Japanese threat from the Pacific, the US military focused its efforts against rising Soviet Communism. Despite its rocky start during World War II, the development of long-range strategic bombers continued to increase momentum. Heavy bombers demonstrated the necessary functional characteristics and only means from which the US could initially employ its growing nuclear arsenal against an adversary halfway around the world.



## B-52 Development

Even during World War II, the US Army Air Forces (AAF) continued its development of longer-range bombers, focusing on an increased intercontinental capability in the XB-36 program. First flying in 1946, the XB-36's six turbofan engines proved incapable of producing enough speed to outrun fighter attacks. The heavy and unmaneuverable aircraft still required fighter escorts, even after Convair later augmented it with four auxiliary jet engines.[1] Consequently, plans for the development of its replacement, the XB-52, began as early as 1946, the same year Strategic Air Command (SAC) stood up and one year before the US Air Force became an independent service.

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[1] Lori S. Tagg, *Development of the B-52: The Wright Field Story* (Wright Paterson AFB, OH: Aeronautical Systems Center, 2004), 5.

The development of the XB-52 began during a dedicated bomber consolidation effort. During the war, the AAF employed at least seven different bomber aircraft and multiple attack aircraft.[2] The AAF's Bombardment Branch sought to simplify future bomber development into three aircraft: one heavy, one medium, and one light. It initially defined its desired characteristics for a high-speed, high-altitude, all-weather heavy bomber capable of a 5,000-statute mile combat radius. Engine and aircraft technology available immediately after the war would prove unable to meet this lofty challenge, but SAC nonetheless needed an aircraft capable of reaching global targets from the continental US.[3]

From 1946 until Boeing received an initial production contract for the XB-52 in 1951, emerging technologies and the USAF's requirements changed at a rapid pace. The XB-52's final propulsion system changed from four turboprops to eight turbojet engines. Boeing and the USAF added air refueling capability, explored swept and tapered wing technology, switched the cockpit from tandem to side-by-side seating, extended the wing span, explored low-altitude penetration flight regimes, and limited the XB-52's self-armament to only four guns located in the tail section. The USAF also required a manned reconnaissance capsule that could fit into the XB-52 bomb bay after scrapping its initial plans to build a separate strategic reconnaissance aircraft. At one point in 1951, SAC favored a "long-range, high-speed" reconnaissance mission for the XB-52 instead of using the new platform to modernize the bomber force.[4] With the advent of the U-2 by 1955, however, the XB-52's primary mission returned to strategic bombing. Balancing technology, design tradeoffs, and the potential range air refueling offered long-range missions, by 1949 the Air Force settled on a final unrefueled radius of

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[2] Tagg, *Development of the B-52, 8.*
[3] Tagg, *Development of the B-52,* 103-113.
[4] Tagg, *Development of the B-52, 76, 85.*

4,000 nautical miles.[5] Boeing's initial design concept proved successfully adaptable despite the massive requirements changes, the difficulty integrating jet engines that could produce the desired range, and constant threats to rebid an entirely new bomber. Boeing ultimately maintained its contract and turned the XB-52 into the USAF's first jet-propelled heavy bomber.

Many of the requirements changes during the initial development phase directly resulted from the evolving threats of the Cold War. The Berlin Airlift in 1948 illustrated the escalation of conflict with the Soviets and underlined the importance of improved strategic military capability.[6] By 1949 Gen Curtis LeMay, commander of SAC, realized the relatively slow B-36 needed an operational replacement within five years to counter improved Soviet air defenses.[7] That same year, the USSR tested and detonated its first atomic weapon, a few years sooner than the US anticipated. The strategic impact of this event caused the Department of Defense (DOD) to accelerate its nuclear delivery system procurement and its production of a hydrogen weapon. The 1954 and 1955 Soviet May Day parades debuted new turbojet Mya-4 Bison and intercontinental Tu-95 Bear aircraft. Although the US miscalculated Soviet production capability and overestimated the numbers of these new bombers in the Soviet inventory, the potential bomber gap further spurred SAC's dedication to producing large numbers of high performance nuclear delivery vehicles.[8]

At this point in XB-52 development, a study by RAND Corporation sparked a debate concerning quantity versus quality in bomber procurement.[9] The study maintained higher quantities of air-refuelable

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[5] Michael E. Brown, *Flying Blind: The Politics of the U.S. Strategic Bomber Program* (Ithaca: Cornell University Press, 1992), 132.
[6] Tagg, *Development of the B-52, 45.*
[7] Tagg, *Development of the B-52, 63.*
[8] Brown, *Flying Blind*, 153-154.
[9] Tagg, *Development of the B-52, 64-65.*

medium-range bombers would provide a force to counter the rising Soviet threat quicker than solving the range, speed, and payload problems of the larger jet-propelled XB-52. Proponents of the XB-52 like Gen LeMay, however, realized the importance of a dedicated high-performance bomber. Such a heavy bomber offered greater flexibility by carrying heavier payloads, superior speed and altitude, and the option of introducing heavy reconnaissance and other capsulized packages into the bomb bay. Furthermore, with the Korean War starting in 1950, the DOD all but removed the post-World War II funding limits for the development of strategic weapons.[10] The developing Cold War, coupled with the outbreak of fighting in Korea, reduced post-World War II military fiscal restraint.

The heavy bomber Boeing provided to the Air Force in 1955 underwent numerous upgrades, to include seven different service models. Development initially followed a sequential pattern as Boeing flight-tested prototypes before the USAF committed to production. This offered the Air Force flexibility as their requirements and technology could change before the Air Force sank greater funds into production airframes.[11] The Air Force finally decided in 1951 to commit to production and expedite the B-36 replacement. This decision resulted in a concurrent development strategy in which aircraft production began before the Air Force agreed to the final design configuration. From that point, Boeing produced 88 less capable aircraft prior the first highly produced D-model.[12] Despite this costly change in acquisition strategy, the B-52 maintained a high degree of flexibility throughout its career as it adapted to new weapons and mission sets. Boeing ultimately produced 744 B-52s in total, and the USAF today still flies the last H models delivered in 1962.

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[10] Tagg, *Development of the B-52, 68.*
[11] Brown, *Flying Blind*, 147-148.
[12] Brown, *Flying Blind,* 151.

## B-52 Employment

Every production B-52 belonged to SAC. B-52s initially carried only nuclear weapons, and their crews trained solely for the nuclear mission against the USSR. Capable of delivering both gravity and air-launched nuclear missiles, the B-52 provided US leadership with a visible nuclear signaling option. Compared to Intercontinental Ballistic Missiles, the B-52 offered a means to launch nuclear-armed bombers toward an adversary with the option to recall them if the conflict could be averted. Prior aircraft dispersal and those B-52s launched due to strategic nuclear warning could also provide a means of survivability for a portion of the nuclear arsenal should the US receive a devastating first strike by the USSR. Although the US never employed B-52s on a fully executed nuclear mission, they provided continuous 24-hour airborne nuclear alert as aircraft carrying nuclear weapons flew Chrome Dome missions over the Arctic. Persistent airborne nuclear alert continued until 1968 when a fire forced a crew to eject from a nuclear-armed B-52 on a Thule Monitor flight, resulting in the loss of the bomber and four nuclear weapons.[13] Bomber strategists and war planners could only measure the B-52's value in fulfilling its Cold War nuclear role by the fact nuclear war never occurred. Even without bombers maintaining an airborne nuclear alert status, leadership could signal its resolve by launching nuclear-armed bombers and still maintain the option to recall them before further nuclear escalation. The B-52 therefore offered a nuclear strike and deterrent characteristic unparalleled by other aircraft and weapon systems.

The B-52 remained on ground nuclear alert until 1991 when the Soviet Union fell and the Cold War ended. In addition to its nuclear capability, Boeing conducted some conventional weapons testing during

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[13] L. Douglas Keeney, *15 Minutes: General Curtis LeMay and the Countdown to Nuclear Annihilation* (New York: St. Martin's Press, 2011), 317-318.

the development of the XB-52. The USAF, however, did not initially purchase conventional capability for production-level B-52s.[14] As the Vietnam conflict began to escalate in 1965 SAC retrofitted a large portion of the fleet to deliver conventional weapons.[15] The USAF took 200 B-52s out of the nuclear alert cycle and deployed them to Guam and Thailand for conventional combat in Vietnam. Stagnant SAC bombing tactics proved the initial B-52 Electronic Warfare (EW) suite incapable of providing sufficient defense for the aircraft against modern Soviet air defenses. By 1972, the coordinated aerial support packages flown with large B-52 formations in Operations Linebacker I and II coupled with better defensive tactics decreased the B-52 loss rate from 6% to 2% in spite of increased North Vietnamese air defenses.[16] First utilized in Operation Rolling Thunder, B-52s attacked limited target sets in South Vietnam that provided close air support and limited interdiction-type effects for the Army.[17] However, they produced little strategic effect based on the types of targets politically chosen to restrain the escalation of conflict.[18] During Linebacker I and II, US leadership adjusted their strategy and employed the B-52 against power grids, airfields, rail yards, shipyards, and communication nodes in North Vietnam.[19] Not yet able to carry the laser-guided precision weapons of the day, the B-52 still produced substantial strategic results using carpet-bombing techniques. In contrast to the bombers of World War II, the B-52's massive multi-

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[14] David S. Sorenson, *The Politics of Strategic Aircraft Modernization* (New York: Praeger, 1995),125.
[15] Thomas C. Hone, "Strategic Bombardment Constrained: Korea and Vietnam," in *Case Studies in Strategic Bombardment,* ed. R. Cargill Hall (U.S.: Air Force History and Museums Program, 1998) 496.
[16] Hone, "Strategic Bombardment Constrained," 516.
[17] Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca: Cornell University Press, 2000), 23.
[18] Ian Horwood, *Interservice Rivalry and Airpower in the Vietnam War* (Ithaca: Dept. of the Army, 2009), 163.
[19] Steven J. Lambakis, "America's Option: The Long-Range, Land-Based Bomber," in *The B-2 Bomber: Air Power For the 21st Century,* eds. Keith B. Payne and John J. Kohout III (Ithaca: University Press Of America, 1995), 27.

payloads and relatively accurate bombing system produced psychological effects on its adversary, denied its adversary's ability to wage war, and limited civilian casualties.[20] The result produced measurable strategic effects and ultimately reinvigorated a stalled negotiation process with the North Vietnamese.

After Vietnam, the USAF did not employ the B-52 in conventional combat again until Desert Storm. As the Cold War faded, SAC again released a portion of B-52s from their nuclear mission to a conventional role in Desert Storm. In a campaign first defined by new precise systems capable of surgically destroying the Iraqi command and control networks and air defenses, B-52s contributed their legacy capabilities and massive payloads to deliver strategic effect. B-52s fired Conventional Air Launched Cruise Missiles (CALCMs) as a standoff platform, offering first-strike capability at the beginning of the air war despite their inability to penetrate far into Iraq's air defenses. B-52s also executed low-level area attacks against forward Iraqi airfields within the first few hours of the war, helping achieve air superiority for Coalition Forces.[21] Once the heavy bombers could penetrate the degraded Iraqi air defense system, they exhibited their conventional versatility, similar to Vietnam, by attacking area targets such as ammunition stockpiles, industrial complexes, and troop concentrations with unguided weapons. B-52s also attacked interdiction targets in support of ground troops such as Iraqi armor and artillery. According to *The Gulf War Air Power Survey*, "the least accurate platform in the Coalition inventory, the B-52, had the greatest impact on [Iraqi] morale."[22] As the only heavy bomber employed in this theater, the B-52 dropped 30% of the total tonnage during Desert

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[20] Hone, "Strategic Bombardment Constrained," 518.
[21] Richard G. Davis, "Strategic Bombardment in the Gulf War" in *Case Studies in Strategic Bombardment,* ed. R. Cargill Hall (U.S.: Air Force History and Museums Program, 1998) 568.
[22] Quoted in John Andreas Olsen, "Operation Desert Storm, 1991," in *A History of Air Warfare,* ed. John Andreas Olsen (Ithaca: Potomac Books Inc., 2010), 194.

Storm,[23] demonstrating large unguided payloads still provided utility to a combatant commander fighting a large fielded force.

The B-52's standoff capability proved critical in several other post-Desert Storm conflicts as its radar cross section rendered it unable to penetrate modern air defenses. During Operation Desert Strike in 1996 and again during Operation Desert Fox in 1998, the US required aircraft capable of flying long ranges around denied airspace to deliver CALCMs against Iraqi targets.[24] In these cases, the US desired quick kinetic effects to force Iraq to meet its post-Gulf War responsibilities and permit United Nations weapon inspections. Unlike the Desert Storm conflict, a large buildup of forces would have been disproportionately costly to meet the desired ends. A multi-platform Integrated Air Defense System (IADS) takedown plan proved unnecessary in this scenario since the B-52s offered range and standoff capability.

Similar to Desert Storm, the Air Force further developed a new strategy of employing heavy bombers as part of an expeditionary aerospace force in Operations Allied Force, Enduring Freedom, and Iraqi Freedom. The Air Force employed all three heavy bombers (B-52s, B-1s and B-2s) in its inventory during each of these conflicts, maximizing the capabilities and quantities of each.[25] In relatively uncontested air space, B-52s and B-1s provided loiter time, reach across the battlespace, and payload not available from other platforms. The B-52 also employed precision weapons for the first time in Enduring Freedom by dropping Joint Direct Attack Munitions (JDAMs).[26] Able to mix its payloads, the B-52 could provide close air support (CAS) to ground troops with its precision arsenal and attack precoordinated area targets like training

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[23] Rebecca Grant, *Return of the Bomber: The Future of Long-Range Strike,* Air Force Association Special Report (Arlington, VA: Air Force Association, February 2007), 10.
[24] Grant, *Return of the Bomber,* 12-13.
[25] Frank P. Donnini, *Battling For Bombers: the U.S. Air Force Fights For Its Modern Strategic Aircraft Programs* (Ithaca: Praeger, 2000), 128.
[26] Lambeth, "Operation Enduring Freedom," 270.

camps with unguided weapons on the same mission.[27] Furthermore, precision standoff CALCMs remained a substantial night-one weapon. Finally, the Air Force retrofitted the B-52 with Advanced Targetting Pods for Enduring Freedom, opening a capability to provide greater time sensitive targeting (TST) capability to support ground forces as well as the ability to strike moving targets. These campaigns further proved the B-52s inherent flexibility and worth in expeditionary conflict.

## Conclusion

Like the B-17 during World War II, the B-52 today offers *range*, *persistence, penetrant strike*, and *flexibility*. First, the advent of an air-refuelable jet-propelled platform offered unprecedented *range* for a heavy bomber. Crew fatigue and other aircraft consumables became the new limitations for aircraft sortie duration. Second, in a conventional role, the B-52 offered the combatant commander *persistence* defined by increased loiter time over the battlespace. Due to its large production number of 744 aircraft, the B-52 also provided constant air and ground alert aircraft during the height of the Cold War. Fulfilling the airborne nuclear alert role exemplified *persistence* as B-52s provided constant 24-hour airborne coverage along northern polar routes. While the B-17 required fighter escorts to achieve its third functional characteristic of *penetrant strike*, the B-52 initially offered autonomous strike capability essential for SAC. Designed as a 1950s penetrating bomber, it could employ low-altitude radar-evading tactics in combination with its own electronic counter measures (ECM) to penetrate the Soviet defenses of that era. The B-52 now offers a substantial standoff capability in contested battlespaces. It still offers first-strike capability in these theaters because the cruise missile assumes the penetrating role. Once the battlespace becomes uncontested, the B-52 can then offer *precision*

[27] Benjamin S. Lambeth, "Operation Enduring Freedom, 2001," in *A History of Air Warfare,* ed. John Andreas Olsen (Ithaca: Potomac Books Inc., 2010), 259.

CAS and interdiction capability. Concerning its self-defense capabilities, the USAF continually upgraded the B-52's internal EW suite throughout its lifespan and integrated its employment tactics with other platforms capable of better suppression and destruction of enemy air defenses (SEAD/DEAD). The B-52's upgradability, therefore, contributes to the fourth resonating characteristic of *flexibility*. Initially conceived as a nuclear delivery and strategic reconnaissance aircraft carrying internal payloads, the USAF added conventional weapons, wing hard points to mount external weapons, *precision* munitions capability, and *precision* navigation utilizing the global positioning system (GPS) to the B-52. The USAF also added an infrared pod and steerable television camera for better visibility in the low-level regime.[28]

In addition to the four functional characteristics shared with the B-17, the B-52 also provides three additional characteristics summarized in Table 2. First, it carries a greater array of weapon types than any other platform. From nuclear gravity weapons and missiles to iron bombs, mines, cluster munitions, and an assortment of smart weapons, the B-52 offers the functional characteristic of *multi-payload* to the combatant commanders. Second, the introduction of GPS-guided gravity and standoff weapons as well as laser-guided weapons gives the B-52 a quality of *precision* that maintains its relevancy against today's target sets. Smart weapons bridge the gap from carpet-bombing in Vietnam to today's minimal threshold for collateral damage. *Precision* weapons enable the B-52 to assume CAS and standoff roles fifty years after its inception. Third, the B-52's nuclear signaling, recallability, strike, and hardening capabilities in addition to its ability to protect nuclear weapons for a second-strike further set it apart from any other platform. *Deterrence* encapsulates these capabilities in a seventh functional characteristic. The longest-serving heavy bomber in the USAF, the B-52

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[28] Sorenson, *Strategic Aircraft* Modernization, 160.

underwent several significant modifications germane to the changes in the strategic environment. Throughout the Cold War, Vietnam, Desert Storm, Allied Force, Enduring Freedom, and Iraqi Freedom, the B-52 continues to maintain the functional characteristics of *range*, *persistence*, *penetrant strike*, *flexibility*, *multi-payload*, *precision,* and *deterrence* for the USAF.

**Table 2: B-52 Functional Characteristics**

| Functional Characteristic | B-17 | B-52 |
|---|---|---|
| Range | X | Strike USSR from US with air-to-air refueling |
| Persistence | X | Fleet capable of constant air/ground alert |
| Penetrant Strike | X | Low-altitude Soviet defense penetrator with ECM |
| Flexibility | X | Versatile strike options and upgradeability |
| Multi-Payload | | Employs vast range of kinetic weapons |
| Precision | | Minimizes collateral damage |
| Deterrence | | Credible nuclear second-strike capability |

*Source: Author's Original Work*

Chapter 3

B-2 Spirit Case Study

The strategic environment of the Cold War directly influenced the initial development of the B-2. During Vietnam, the B-52 showed signs it would not be able to penetrate future Soviet air defenses.[1] The Carter administration, therefore, debated the usefulness of developing another penetrating bomber to replace the aging B-52 versus developing cruise missile technology and a strategy utilizing standoff platforms. They began research and development toward the B-1A, then cancelled this program claiming, "B-52s as standoff bombers would maintain the effectiveness of the air-based leg of the strategic triad at lower cost."[2] The Carter administration did not, however, shun penetrating bombers altogether. Secretly in 1975, the USAF tasked a small group of Northrop and Lockheed engineers to begin classified research on stealth technology. Lockheed's work ultimately resulted in the F-117 while Northrop's project would become the Advanced Tactical Bomber (ATB). The advent of a stealthy long-range bomber demonstrated the enduring functional characteristics of the B-17 and B-52 by reinvigorating penetrant strike capability in a changing strategic environment highlighted by new advanced air defense systems. The stealth bomber also added an economy of force not yet seen from other bombers due to its precision, large multi-payload, and autonomy.[3]

## B-2 Development

Under the Reagan administration, the Department of Defense (DOD) planned to modernize its aging nuclear triad. In addition to the

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[1] David S. Sorenson, *The Politics of Strategic Aircraft Modernization* (New York: Praeger, 1995), 165.

[2] Congress of the United States Congressional Budget Office, *The B-1B Bomber and Options for Enhancements* (Washington D.C.: U.S. Government Printing Office, August 1988), x.

[3] See note 32 on page 34.

cruise missile development started under Carter, the USAF sought to produce two new strategic aircraft to replace the B-52. The USAF first revitalized the B-1A program as a rapid replacement for the B-52's waning penetration capability. In contrast to the B-52, the new B-1B would provide low-altitude, high speed, reduced radar cross-section capability against Soviet air defenses.[4] When employed in this regime, the B-1B would provide penetrating capability until the ATB would become operational sometime in the 1990s, at which point the B-1B could provide standoff capability. The ATB, later called the B-2, would deliver long-term penetration capabilities into highly modernized air defenses as the first stealth bomber. The USAF at that time justified the simultaneous development of both aircraft since the USSR spent "three times as much on defense as the US spent on offense, including strategic aircraft."[5] The US had to maintain a balance of effective strategic forces to maintain its nuclear deterrent credibility.

As B-2 full-scale development began in 1981 and continued throughout the 1980s, the USAF perceived it as a multi-role, long-range bomber with both high and low-altitude capability.[6] Unlike the development of the B-52, the B-2 would support the main US nuclear war plan as well as provide conventional attack capability from its inception rather than upgrade to conventional capability after production. The USAF also required an aircraft capable of a 6,000 nautical mile unrefueled range, a 50,000-pound payload, and low observable features not only in airframe design, but also in acoustic and infrared signature.[7] After the advent of the F-117, the strategic environment for strike aircraft began to change. Adversarial air defense systems revealed new, asymmetric techniques for tracking and targeting

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[4] Congressional Budget Office, *B-1B Bomber*, ix.
[5] Frank P. Donnini, *Battling For Bombers: the U.S. Air Force Fights For Its Modern Strategic Aircraft Programs* (Ithaca: Praeger, 2000), 112.
[6] Sorenson, *Strategic Aircraft Modernization*, 167.
[7] Donnini, *Battling For Bombers*, 105.

stealth aircraft to include searching for other types of aircraft emissions. By smoothing highly reflective corners into a single blended wing, introducing radar absorbent materials, hiding the cockpit, and masking the engine intakes and exhaust heat signatures, designers could radically reduce the radar, noise, and heat signatures of a heavy bomber. These stealth design characteristics, coupled with proper flight regime tactics, would render the B-2 difficult to impossible for Soviet air defenses to find and track.

Realizing the complexity of these demands and the length of time needed to develop these radically new technologies, the USAF required 100 B-1B aircraft as an interim capability until Northrop could deliver the B-2. Costly requirements changes coupled with over 900 new manufacturing processes needed to develop the radical technologies of a stealth bomber delayed B-2 deliveries to the USAF. For instance, intelligence showed advances in Soviet look-down/shoot-down fighter radars and low-altitude surface-to-air missile systems would eventually threaten the B-1's low-altitude penetrating capability.[8] In 1984, relatively late in the design phase, the USAF therefore required a low-altitude flight regime capability for the B-2.[9] Operation in this harsher low-altitude environment required costly airframe and avionics redesigns. When the B-2 became operational in the late 1990s, however, training in the low-altitude flight regime proved costly in terms of airframe maintenance and offered little utility after the fall of the Soviet Union. The change in the post-Cold War strategic environment forced the USAF to drop the low-altitude penetration profile from the B-2's array of capabilities despite its expense during the design phase.

As B-2 development overcame several design obstacles, the USAF's overall procurement plan hit a wall of fiscal restraint. The original plan

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[8] Michael E. Brown, *Flying Blind: The Politics of the U.S. Strategic Bomber Program* (Ithaca: Cornell University Press, 1992), 275.
[9] Brown, *Flying Blind*, 297.

called for 132 B-2 bombers to cover the Soviet target set dictated by strategic nuclear plans in the early 1980s.[10] In 1988, the USAF unveiled the secret aircraft to the public, but the resulting transparency of increasing program costs coupled with a waning Cold War brought about a reduction in programmed B-2 end-strength by 1990. After the fall of the Berlin Wall, the Bush administration initially reduced the planned B-2 fleet to 75 aircraft.[11] This number would have coincided with the next (Clinton) administration's Bottom-Up Review (BUR) concerning force structure planning. The BUR outlined a strategic environment defined by unsettled post-Cold War regional states and rogue actors proliferating weapons of mass destruction.[12] Consequently, the US postured itself to respond simultaneously to two Major Regional Conflicts (MRC), requiring 184 bombers. The USAF had already purchased 100 B-1s, so 75 B-2s along with several remaining B-52s to cover nuclear commitments could have covered the two-MRC strategy. Yet by 1992, before Clinton's BUR, the Bush administration reduced the final buy to 20 aircraft, only five more than Congress wanted to fund in a solely conventional role.[13] The declining requirement for a new nuclear strike capability after the fall of the Soviet Union, coupled with a post-Gulf War military drawdown, reduced the need for a large number of technologically expensive bombers. Since the BUR occurred well after the cut to 20 aircraft, budgetary concerns primarily drove the final procurement decision.

In 1994, the decision to produce only 20 B-2 aircraft finally demonstrated some strategic justification with the publication of a Nuclear Posture Review (NPR). The NPR called for 20 B-2s, 66 B-52s, three intercontinental ballistic missile (ICBM) wings, and 14 nuclear

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[10] Quoted in Bernard C. Victory, "The B-2 and U.S. Domestic Politics," in *The B-2 Bomber: Air Power For the 21st Century,* eds. Keith B. Payne and John J. Kohout III (Ithaca: University Press Of America, 1995), 104.
[11] Sorenson, *Strategic Aircraft Modernization*, 178.
[12] Charles M. Perry et al., *Long-Range Bombers & the Role of Airpower in the New Century* (New York: Inst for Foreign Policy Analysis, 1995), 28-29.
[13] Donnini, *Battling For Bombers*, 109.

submarines to cover the post-Cold War nuclear threat.[14] Advocates for increasing the role of the bomber in the triad maintained that Strategic Arms Reduction Treaty (START) restrictions counted bombers as only one warhead. Because each delivery vehicle could carry multiple nuclear weapons, bombers offered the opportunity to retain more nuclear warheads in the inventory. The B-2 further contributed deterrence, flexibility, diversity of payload, and recallability to the triad.[15] The B-2's potential nuclear capability provided relevant arguments to justify its increasing developmental costs during the Cold War, but the conclusions presented by the 1994 NPR ended any plans to keep the B-2 production line open for future buys. The last operational B-2 upgrade occurred when the Clinton administration later authorized funding to convert the remaining prototype test bed into the 21st and final combat-coded aircraft.

When designing penetrating aircraft systems against Soviet defenses, the USAF considered the factors of speed, altitude, reduced radar cross section, and jamming.[16] While the B-52 and B-1 had difficulty maintaining viable electronic warfare (EW) defenses against improving Soviet air defenses, the B-2 designers sought to negate this problem with stealth technology and tactics. Continuing with the penetrating aircraft strategy rather than solely relying on cruise missiles, the USAF would use the B-2 to hold at risk hardened targets and well-defended Soviet nuclear forces in addition to mobile or dispersed targets. Continually seeking an asymmetric advantage during the Cold War, the USSR changed the strategic environment by placing many of its nuclear weapons on mobile launchers. This created a targeting dilemma for the US, provided the Soviets greater protection of their nuclear forces, and ensured them a greater second-strike capability. Finding and targeting

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[14] Quoted in Perry et al., *Long-Range Bombers*, 8-9.
[15] Donnini, *Battling For Bombers*, 120.
[16] Donnini, *Battling For Bombers*, 116.

mobile Soviet ICBMs, therefore, became a primary mission for the B-2 during its development.[17] An airborne capability that could seek out and destroy remaining mobile missiles during a retaliatory attack against the USSR would limit further volleys and damage to the US. Maintaining a penetrating capability that could attack relocatable military targets and leadership facilities further synthesized the B-2 with contemporary nuclear war plan strategy and helped sustain its Congressional funding.[18]

As the Cold War faded, the penetrating argument for the B-2 in a conventional role also helped keep the program alive. The F-117's success during Operation Desert Storm proved the value of an even larger stealth penetrator. From a capability standpoint, the B-2 offered 10 times the payload and five times the range of the F-117.[19] Proponents for the B-2 argued it could attack heavily defended targets, such as command and control nodes, weapons of mass destruction (WMD) caches, and air attack assets in the first strikes of a campaign.[20] The B-2 promised a massive reduction in escort, jamming and other support aircraft required for large strike packages.[21] By launching and recovering to bases within the US, it could strike multiple targets without the large force buildup and forward basing required for Desert Storm. The B-2's element of surprise coupled with global strike capability would become useful in cases where limited targets required quick kinetic effects without engaging larger forces in a sustained conflict. Furthermore, USAF leadership compared the B-2 to naval aircraft carriers in terms of both cost and firepower.[22] "Eight B-2s would have

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[17] Sorenson, *Strategic Aircraft Modernization*, 166.
[18] Sorenson, *Strategic Aircraft Modernization*, 193, 202.
[19] Donnini, *Battling For Bombers*, 118.
[20] Donnini, *Battling For Bombers*, 126.
[21] Sorenson, *Strategic Aircraft Modernization*, 17.
[22] Steven J. Lambakis and John J. Kohout III, "The Cost-Effectiveness of the B-2 Bomber," in *The B-2 Bomber: Air Power For the 21st Century,* eds. Keith B. Payne and John J. Kohout III (Ithaca: University Press Of America, 1995), 182-183.

the same long range striking power as one aircraft carrier battle group and do the mission without needing to depend on foreign base access."[23] Since the final B-2 procurement stopped at only 21 aircraft, the B-2 fleet would not ultimately provide the persistence necessary to engage in large conflicts by itself without other strike platforms. However, it could attack an adversary's critical air defense nodes and open corridors for other non-stealthy aircraft. Despite its low quantity, the B-2 still provided great potential as a penetrating heavy bomber.

Due to the lengthy research and development timeline associated with the B-2, the USAF permitted a concurrent B-2 production strategy. The USAF accepted production risk before deciding on the final design and counted on its future ability to upgrade certain B-2 capabilities so it could receive its first B-2s by 1993. Similar to most modern military aircraft acquisition programs, Northrop Grumman, therefore, delivered the B-2 fleet in a series of blocks defined by systems and capability upgrades.[24] The first Block 10 aircraft could carry 16 gravity nuclear weapons or 2,000-pound MK84 iron bombs, but did not have precision weapon capability.[25] With the advent of the global positioning system (GPS) and the navigational capabilities it offered by the mid-1990s, Block 20 B-2s could carry 34 cluster bombs or 16 2,000-pound guided bomb unit (GBU)-31s. The GBU-31 became the first widely utilized Joint Direct Attack Munition (JDAM) and offered unprecedented precision to gravity bombing. The Block 20 also offered a revolutionary capability with its GPS-Aided Targeting System (GATS). This system enabled the crew to improve the accuracy of its precision weapons by reducing target location error, GPS biases, and system navigation errors. Having *a priori* knowledge of a target area, crews could autonomously utilize the B-2's

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[23] Quoted in Donnini, *Battling For Bombers*, 121.
[24] Northrop Corporation acquired Grumman Aerospace Corporation in 1994. The author refers to the B-2 manufacturer as Northrop Grumman from this point forward.
[25] Don Logan, *ACC Bomber Triad: the B-52s, B-1s, and B-2s of Air Combat Command* (Atglen, PA: Schiffer Publishing, Ltd., 2004), 239-240.

synthetic aperture radar (SAR) to visually identify weapon impact points and derive precise target coordinates for both fixed and mobile threats real-time. Utilizing its stealth characteristics, an unaccompanied B-2 could attack these types of targets through weather with precision weapons. GATS improved target accuracy while eliminating the dependency for off-board targeting sensors from other platforms. Finally, Block 30 B-2s added the capability to carry mines, 750-pound class gravity weapons, and up to 80 500-pound iron bombs. This final iteration also provided radar upgrades, terrain-following capability, and the framework for eventually carrying 80 GBU-38 JDAMs.

Further B-2 upgrades appeared as avionics software suites. By 1996, the B-2 reached initial operating capability (IOC) after proving its ability to prosecute multiple targets on a single pass with precision weapons. Over the next few years, the B-2 received upgrades to carry 5,000-pound penetrating weapons, the Joint Standoff Weapon (JSOW), and the Joint Air-to-Surface Standoff Missile (JASSM).[26] In 2011, the B-2 became the first certified aircraft to drop the 30,000-pound GBU-57 Massive Ordnance Penetrator (MOP). This weapon provides capability to reach deeply buried and high value targets such as leadership bunkers, command and control nodes, and weapon production or storage facilities. Thus, as the strategic environment moved away from nuclear strike and toward conventional penetrant strike capability against hardened and heavily defended targets, the capabilities Northrop Grumman designed into the B-2 through both its original production aircraft and its history of upgrades provided the enduring functional characteristics of range, penetrant strike, flexibility, multi-payload, and precision. These characteristics proved vital as the B-2 began its operational roles for the USAF.

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[26] Donnini, *Battling For Bombers*, 126.

## B-2 Employment

The B-2 made its combat debut in 1999 during Operation Allied Force (OAF). The first heavy bomber to employ precision guided munitions, the B-2 proved vital during night-one operations in a conflict earmarked by NATO's unwillingness to accept collateral damage from errant air strikes.[27] As the conflict progressed, the coalition would rely solely on airpower to provide the kinetic means to win the war as the deployment of ground troops became politically unacceptable. Despite these restrictions and its initial inception as a Cold War nuclear delivery platform, the B-2 presented unmatched conventional capability. Able to penetrate Serbian air defenses without detection, it delivered the first air strikes with precision-guided JDAMs against critical command and control nodes. The B-2 proved the operational effectiveness of these new weapons as the first Combat Air Force (CAF) asset fitted with this capability.[28] Throughout the 78-day conflict, six B-2s operating out of Missouri flew just 45 of the 9,500 total coalition strike sorties. Despite their mere half of a percent of the sorties flown, they released over 11 percent of the bombs dropped in Serbia and Kosovo.[29] Since the USAF had not yet integrated the relatively new JDAM into the B-1 and B-52 platforms, the B-2 held a niche capability at that time to attack targets through weather that otherwise grounded other attack aircraft. As the Serbian conflict progressed, USAF leadership required greater retargeting flexibility from the B-2.[30] After the lengthy 13-15 hour ingress, crews improved their communications practices and tactics, including greater GATS employment, to engage higher priority targets that emerged while they were enroute to Serbia. The B-2's success in OAF validated the

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[27] Tony Mason, "Operation Allied Force, 1999," in *A History of Air Warfare,* ed. John Andreas Olsen (Ithaca: Potomac Books Inc., 2010), 246-247.
[28] Barry D. Watts, *The Case for Long-Range Strike: 21st Century Scenarios,* Center for Strategic Budgetary Assessments (Washington D.C.: CSBA, 2008), 12-13.
[29] Benjamin S. Lambeth, *NATO's Air War For Kosovo: a Strategic and Operational Assessment* (Santa Monica, CA: Rand Corporation, 2001), 90-91.
[30] Watts, *The Case for Long-Range Strike*, 28.

bomber's design functional characteristics of range, endurance, and multi-payload. The B-2 further began a transformation in modern heavy bomber employment during the Serbian conflict. It coupled precision with massive payload because the B-2 could strike a myriad of targets on a single pass instead of flying multiple passes against a single target.[31] Precision weapons, a large multi-payload, and an autonomous penetrant strike capability offered by stealth technology therefore contributed to the functional characteristic of economy of force.[32]

Despite its successes during OAF, the B-2's first combat deployment highlighted several challenges with stealth bomber employment. First, the sortie length to launch from and recover to a CONUS airbase in a high-value, low-density aircraft proved the 21-aircraft fleet could not sustain a war of a higher tempo for an extended duration. Block 30 and other upgrades occurring during OAF rendered half of the fleet unavailable for combat sorties. The USAF would need more aircraft and crews should it require a higher degree of persistence. Second, long sorties presented the potential for increased ground maintenance times for the repair of stealth coatings.[33] Northrop Grumman dedicated significant resources to minimize maintenance time for low observability (LO) repair work, and their efforts showed some

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[31] Lambeth, *NATO's Air War For Kosovo*, 91.

[32] Sorenson, *Strategic Aircraft Modernization,* 186 and Office of the Secretary of the Air Force, AFDD1, *Air Force Basic Doctrine, Organization, and Command* (United States Air Force, 14 October 2011), 33. AFDD1 defines economy of force as the "judicious employment and distribution of forces" to maximize effort against primary objectives and minimize primary resources against secondary efforts. Here, the author combines precision weapon capability, large multi-payload, and autonomous penetrant strike capability into a new bomber functional characteristic called economy of force because it directly relates to the AFDD1 definition. Because the B-2 could penetrate robust air defenses and deliver various types of precision munitions against a large spectrum of target sets, a single B-2 could attack multiple primary targets on a single mission rather than employing a formation of bombers against a single target. The B-2 minimizes "overkill" and risk to multiple platforms and aircrew by reducing the amount of resources required to defeat a target kinetically. This capability allows for an efficient distribution of resources against primary objectives, similar to the AFDD1 definition, and makes other resources available for secondary efforts.

[33] Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca: Cornell University Press, 2000), 159.

dividend during OAF. Longer conflicts with increased B-2 sortie demand, however, would require improved technology and maintenance practices in this area. Third, the classified nature of the B-2 program and its capabilities made its integration into NATO's air war difficult. The USAF required a second air tasking order concealed from the coalition's efforts for stealth aircraft due to sensitivities surrounding its employment tactics and techniques.[34] The B-2 in this scenario, therefore, lacked a level of interoperability with the coalition. Finally, stealth aircraft still required some level of off-board electronic counter measure (ECM) support to enhance their ability to penetrate certain air defenses.[35] In order to mitigate certain risks, F-117s and B-2s could not enter certain threat areas without support from radar-jamming platforms. Because of its relatively light ECM requirement compared to non-stealth aircraft, however, the B-2 still offered an unprecedented level of autonomous penetrating capability to the combatant commander during OAF.

Similar to the opening salvos of OAF, the USAF employed the B-2 in Operation Enduring Freedom (OEF) in a manner that saved expensive cruise missiles, ensured penetrability on the opening nights of the operation, and delivered effects against hardened targets located in difficult mountainous terrain. Within a month after the al-Qaeda attacks on the US in 2001, B-2s flew combat sorties for the first three nights of OEF. After that point, the enemy's air defenses became penetrable by non-stealth aircraft, and the USAF achieved air superiority. B-1 and B-52 aircraft also acquired JDAM capability prior to OEF, rendering the all-weather precision weapon niche available to all three heavy bombers. On the first night, B-2s struck Taliban air defense radars and military leadership buildings.[36] On the third night, they attacked deeply buried military leadership havens using 5,000-pound GPS guided penetrating

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[34] Mason, "Operation Allied Force," 246-247.
[35] Lambeth, *American Air Power*, 160.
[36] Benjamin S. Lambeth, *Air Power Against Terror: America's Conduct of Operation Enduring Freedom* (Santa Monica, CA: Rand Publishing, 2005), 79.

weapons. One sortie during this conflict flew for over 44 hours, the longest to date.[37] Crews launched from Missouri and landed in Diego Garcia where an engine-running crew change provided a fresh crew to return the aircraft quickly to its home base. This employment structure offered continuous operations for the relatively small fleet of B-2s and revealed crew fatigue and other non-fuel consumables such as engine oil as the new limits of long-range strike aircraft. Intelligence reports later in OEF led to the launch of B-2s in 2007 for a secret strike against an alleged massing of al-Qaeda leadership, to potentially include Osama bin Laden.[38] After the aircraft launched, the USAF recalled them because either the massing never occurred or the probably of exactly targeting the top al-Qaeda leader may have diminished. The B-2 therefore demonstrated similar functional characteristics during OEF as it had in OAF, but it also exhibited the quality of recallability during conventional operations similar to its nuclear command and control design.

In 2003, the B-2 deployed for the first time to a forward operating location (FOL) in Diego Garcia in preparation for Operation Iraqi Freedom (OIF). Unlike the somewhat passive air defenses found in Afghanistan, Iraq's air threat proved more akin to those encountered in OAF. After Operation Desert Storm, Iraq re-built a robust defense network around its critical leadership and military infrastructure in Baghdad and learned coalition tactics from watching its aircraft enforce the no-fly zones of Operations Northern and Southern Watch.[39] The USAF relied on its stealth penetrating aircraft once again to help gain air superiority and strike critically hardened targets. On the first night of the attack, six B-2s demonstrated remarkable economy of force by destroying 92 targets

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[37] Benjamin S. Lambeth, "Operation Enduring Freedom, 2001," in *A History of Air Warfare,* ed. John Andreas Olsen (Ithaca: Potomac Books Inc., 2010), 272.
[38] Eric Schmitt and Thom Shanker, *Counterstrike: the Untold Story of America's Secret Campaign Against Al Qaeda* (Santa Monica, CA: Times Books, 2011), 114-118.
[39] Thomas Withington, *B-2A Spirit Units in Combat* (New York, NY: Osprey Publishing, 2006), 69-70.

within a five-minute window.[40] Long sorties flown from Missouri coupled with shorter sorties flown by four B-2s deployed to the Diego Garcia FOL provided greater persistence to the combatant commander than the previous two conflicts. By the end of the shock-and-awe air campaign in OIF, B-2s flew 43 sorties against hardened targets, air defenses, airfields, and even fielded forces.[41] By using the FOL, B-2s flew approximately the same number of total sorties during OIF in less than half of the duration of OAF. Missions launched from the FOL reduced sortie duration by half and decreased maintenance turn-around times, rendering these aircraft quickly available for their next combat sortie. Time sensitive targeting techniques once again proved critical in delivering precision munitions against emerging threats. Flexible targeting and persistence highlighted the functional characteristics of the B-2 during OIF.

Unlike its previous combat campaigns, B-2 planners and crewmembers had little time to prepare for Operation Odyssey Dawn (OOD). The UN's decision in 2011 to enforce a no-fly zone over Libya occurred with little time for military buildup. The African theater of operations also lacked pre-positioned strike assets, especially with concurrent conflicts occurring in Afghanistan and Iraq. The UN resolution to protect Libyan civilians from military forces threatening to invade urban areas gave the USAF less than three days to provide assistance before Libyan forces attacked the city of Benghazi.[42] In order to deny the Libyan Air Force use of its strike aircraft against rebel forces and civilians in Libyan urban areas, the USAF sent three B-2s on the first OOD mission to strike 45 hardened aircraft shelters (and the aircraft therein).[43] Employing B-2s in this manner demonstrated the

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[40] Jeff Goldblatt and Liza Porteus, "B-2 Bombers Lead 'Shock and Awe,'" *FoxNews.com,* March 26, 2003, http://www.foxnews.com/story/0,2933,82262,00.html (accessed 18 March 2012).
[41] Withington, *B-2A Spirit Units in Combat*, 72-73.
[42] John A. Tirpak, "Lessons from Libya," *Air Force Magazine*, December 2011, 36.
[43] Brig Gen Scott Vander Hamm (Commander, 509th Bomb Wing), interview by Steve Inskeep, *B-2 Bombers from Missouri hit Libyan Targets*, NPR, 21 March 2011,

responsiveness of long-range strike aircraft to quickly evolving threats and once again proved the relevance of stealth aircraft on the opening strikes against an untested Integrated Air Defense System (IADS). The B-2 enabled quick global strike effects when other short-range strike assets and their supporting tankers and electronic countermeasure platforms needed time to forward deploy and coordinate attacks. In this case, the approval process needed to form an execution order became the limiting factor. The B-2s launched from Missouri and flew halfway to their target before receiving the order to strike.[44] This type of mission illustrated the B-2's prompt global strike capability due to its long range, flexible payload, and stealth penetrating characteristics rendering it nearly autonomous in the threat area. The B-2s required mainly a long-range tanker bridge to succeed in this campaign.

**Conclusion**

The USAF and Northrop Grumman designed the B-2 in reaction to improvements in Soviet air defense capability, not to match Soviet bomber development.[45] The B-2's capability to visually seek, using its SAR, and destroy mobile targets in a heavily defended Cold War strategic environment directly translated to conventional capability. As the strategic environment required less nuclear and more surgical-strike capability with conventional munitions, the B-2 became the first platform modified to carry GPS-guided gravity weapons and employ them in combat. The B-2, therefore, exhibits the functional characteristic of *precision.* Like its predecessors, it also maintains the aforementioned functional characteristics of *range*, *persistence*, *penetrant strike*, *flexibility*, *multi-payload,* and *deterrence*. Unlike its predecessors,

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http://www.npr.org/2011/03/21/134726240/No-Fly-Zone-Enforcer/ (accessed 14 March 2012).

[44] Tirpak, "Lessons from Libya," 36.

[45] The USSR had produced their Blackjack bomber at the same time, similar to the USAF B-1. Sorenson, *Strategic Aircraft Modernization,* 194.

however, the USAF did not produce the B-2 in mass. The post-Cold War strategic environment triggered a period of fiscal restraint that ultimately led to only 21 combat-capable B-2s. The technological complexity involved in the research and development of the B-2's low observable capabilities significantly increased the production cost per aircraft. Because of its small fleet size, the B-2 does not offer the kind of *persistence* provided by earlier, massively produced heavy bombers. When forward deployed, however, it can demonstrate signs of this characteristic by increasing sortie rates and decreasing maintenance turn times. However, another limitation to the B-2's *persistence* included the possibility of daytime visual detection. Lacking active defenses against a visually acquired air threat until the advent of a stealthy fighter, this issue constrained the B-2 to nighttime employment.[46] Finally, the B-2 can *persist* at a tactical level in high-threat areas by providing longer loiter times than other non-stealthy strike platforms. Non-stealth strike aircraft offer, at best, discontinuous effects depending on the availability of supporting aircraft beset by shorter ranges.[47] The defining capabilities of the B-2, when compared to the B-52 and B-1, therefore center on its ability to maintain these seven functional characteristics against advanced air defense systems and threats.

As non-stealthy platforms lost their *penetrant strike* and *deterrence* capabilities, the B-2 returned these characteristics to the US heavy-bomber arsenal and provided flexible response options once again to civilian leadership and combatant commanders alike. Despite its small fleet size, the B-2's greatest contribution to both nuclear and conventional types of warfare came in the form of its stealth technology, enabling it to *penetrate* robust air defenses autonomously. Adversaries

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[46] Barry D. Watts, *Long-Range Strike: Imperatives, Urgency, and Options,* Center for Strategic Budgetary Assessments (Washington D.C.: CSBA, 2005), 12, 57.
[47] John J. Kohout III, "Stealth in Context," in *The B-2 Bomber: Air Power For the 21st Century,* eds. Keith B. Payne and John J. Kohout III (Ithaca: University Press Of America, 1995), 150.

transformed the strategic environment by adjusting their defenses to contend with legacy bombers. The USAF required the B-2 to hold well-defended and deeply buried or hardened targets at risk with *precision* weapons. The B-2 continues to deny sanctuary for these types of targets and offers a prompt *penetrant strike* characteristic unavailable from other long-range standoff or short-range strike aircraft. It combines *precision* weapons, a large *multi-payload*, and an autonomous *penetrant strike* capability into a new *economy of force* functional characteristic non-stealthy platforms cannot equal against an adversary equipped with advanced air defenses.[48] As shown in Table 3, the B-2 propagates *economy of force* in addition to those functional characteristics demonstrated by its predecessors because it minimizes the risk and resources required to strike vital, heavily defended targets. Taken together, the B-2's *range*, *persistence*, *penetrant strike*, *flexibility*, *multi-payload*, *precision, deterrence, and economy of force* offer the basic framework from which the USAF should develop its next long-range strike platform to contend with the future strategic environment.

**Table 3: B-2 Functional Characteristics**

| Functional Characteristic | B-17 | B-52 | B-2 |
|---|---|---|---|
| Range | X | X | Global-strike capable within hours |
| Persistence | X | X | N/A due to minimal fleet size & ops constraints |
| Penetrant Strike | X | X | High-altitude night penetrator |
| Flexibility | X | X | Versatile strike options and upgradability |
| Multi-Payload | | X | Employs vast range of kinetic weapons |
| Precision | | X | Minimizes collateral damage |
| Deterrence | | X | Credible conventional/nuclear strike capability |
| Economy of Force | | | Minimize risk/resources vs. primary objectives |

*Source: Author's Original Work*

[48] See note 32 on page 34.

Chapter 4

Strategic Environments

The end of the Cold War, marked by the economic collapse of the Soviet Union, propelled the US into its current role as a unipolar global hegemon. As tensions eased between the former Soviet and Western military powers, a new strategic environment emerged forcing the US to broaden its strategic outlook. In many ways, the decline of a bipolar near military peer complicated how the US commits resources to improve and sustain its military infrastructure. Nonetheless, the events of the last two decades demonstrate the characteristics of the current strategic environment and provide evidence for how it will transform in the future.

According to the 2011 USAF Strategic Environmental Assessment, globalization, natural resources, demographics, and information offer the greatest potential to influence strategic planning for the USAF in the next two decades.[1] Instead of developing each of these subjects in detail, this chapter limits its description of the current and near future strategic environment to those features specifically relevant to the functional characteristics offered by long-range strike aircraft. While these four global trends interrelate with one another, globalization and its effects on worldwide power distribution as well as the rise of non-state actors continues to necessitate the role of long-range strike capability. This chapter focuses on these aspects of globalization.

## Globalization

The late 1980s marked the beginning of a technological revolution in military affairs (RMA).[2] Advanced technologies in military weapons

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[1] Directorate of Strategic Planning, *US Air Force Strategic Environmental Assessment 2010-2030,* (Headquarters, United States Air Force, Mar 2011), 2.

[2] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military (Cornell Studies in Security Affairs)* (Stanford, Calif.: Cornell University Press, 1994), 258.

and information systems greatly enhanced the efficiency and effectiveness of how the US trains, equips, and wages war. Innovations in civil, or non-military, technologies occurred simultaneously with the RMA and drastically changed the strategic environment. The end of the Cold War thus marked the opening of globalized information and technological floodgates.[3]

Information networks provided the framework for instant and readily accessible communication processes. These networks and processes provide the means for countries and regions to draw closer together into tightly knit webs of economic, political, and informational cooperation and alliances.[4] Because of the effects of globalization, the US must sustain superior capabilities in all domains of warfare in order to maintain dominance as a global hegemon and project a continuous stabilizing influence throughout the world. Rogue nations, terrorist groups, and other non-state actors willing to increase nuclear proliferation and the spread of other weapons of mass destruction (WMD) benefit from the same innovations globalization offers for the spread of peaceful cooperation and democracy. They take advantage of the same technologies, networks and processes employed by friendly actors in order to communicate, advertise, train, equip, and achieve their own objectives.

The RMA has enhanced military conventional capability, improved the precision of weapons, and altered the character of warfare.[5] Innovations in stealth, sensor fusion, and precision strike technologies

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[3] United States Government, *National Security Strategy*, (May 2010), 7.
[4] Richard Kugler, *New Directions in U.S. National Security Strategy, Defense Plans, and Diplomacy: A Review of Official Strategic Documents* (Washington, D.C.: National Defense University Press, 2011), 2.
[5] Robert W. Gaskin, "A Revolution for the Millennium," in *The Emerging Strategic Environment: Challenges of the Twenty-First Century,* Williamson Murray, ed. (Westport, Conn.: Praeger, 1999), 130-132.

provide strategic advantages for the US military.[6] As conventional attack capability becomes more precise, lethal, and instantaneous, it also reduces collateral damage. During the RMA, the deterrent value of nuclear weapons has declined because of increased conventional weapon capability coupled with a new post-Cold War strategic environment. Nuclear weapons now possess less of a stabilizing characteristic against non-nuclear powers than they did against a strong nuclear adversary like the Soviet Union.[7] Since the fall of the USSR, regional powers have demonstrated "relative rapidity with which new—and often destabilizing—weapons are being deployed."[8] Nuclear weapons continue to provide deterrence against nuclear capable adversaries. They do not maintain the same deterrent value against threats armed solely with conventional arms or non-state actors. The 2010 Nuclear Posture Review Report (NPRR) further called for reduced dependence on nuclear weapons in US defense strategy.[9] As a result, the future strategic environment requires a sustained RMA to enhance conventional capabilities and technologies that will continue to form a credible deterrence to counter-proliferation and prevent non-state actors from achieving their destabilizing objectives.[10] In order to maintain global stability and its strategic deterrent niche, the US must increase the effectiveness of its conventional capabilities.

Globalization, a defining characteristic of the current and future strategic environment, complicates the effects of conventional deterrence, but it also provides a framework from which the US can logically dedicate its resources to develop future military capability. The US must find its place "between the poles of full disengagement and assertive engagement

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[6] Charles M. Perry et al., *Long-Range Bombers & the Role of Airpower in the New Century* (Cambridge, Mass.: Inst for Foreign Policy Analysis, 1995), 9.
[7] Kugler, *U.S. National Security Strategy*, 70.
[8] Perry et al., *Long-Range Bombers*, xii.
[9] Kugler, *U.S. National Security Strategy*, 63.
[10] Perry et al., *Long Range Bombers*, xiii.

. . . [where] there is a middle ground that calls for strong but selective engagement on a manageable list of strategic issues where success is both mandatory and achievable."[11] While the 2010 US National Security Strategy (NSS) does not discuss a detailed US force posture or the military capabilities of its adversaries, it defines the international security landscape as complex and uncertain. Among several strategic initiatives, the NSS prioritizes US efforts to prevent further WMD proliferation, stabilize and secure the Middle East, and create a common international order for security.[12] Because globalization has increased the pace of change in both power distribution and the rise of non-state actors, the US must make its own connection between its objectives in the future globalized strategic environment and the means it must have at its disposal to obtain and maintain those objectives.

Compared to the NSS, the 2010 Quadrennial Defense Review (QDR) offers more emphasis on defense strategy, force planning, and resource priorities. It requires modernization of conventional and strategic assets and investment in the concepts of air-sea battle and long-range strike.[13] While the US remains the world's strongest military force, weaker adversaries have and will adjust their means to challenge our asymmetric military advantage.[14] The rise and proliferation of military technologies will continue to decrease US access and limit its abilities to attack certain adversarial targets at will. State and non-state actors alike can hide behind stronger defense systems or perform anonymous maneuvers within globalized networks. From the geospatial perspective, the QDR calls for the US to rebalance its forces within six critical mission sets, one of which focuses on deterring and defeating aggression in anti-access and area denial (A2/AD) environments.[15]

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[11] Kugler, *U.S. National Security Strategy*, 15.
[12] Kugler, *U.S. National Security Strategy*, 150.
[13] Kugler, *U.S. National Security Strategy*, 19.
[14] Gaskin, "A Revolution for the Millennium," 130.
[15] Kugler, *U.S. National Security Strategy*, 24.

Adversaries in the future strategic environment will spend greater resources to defend the strategic nodes they value. For example, adversaries now protect leadership sanctuaries, command and control complexes, WMD caches, and nuclear processing facilities behind walls of advanced air defenses. They are also deeply burying these targets, rendering them safer from contemporary US conventional weapons. A2/AD environments will soon threaten the ability of first-generation US stealth aircraft to penetrate newer air defenses and their ability to hold highly defended targets at risk. In order to maintain its military advantage in the globalized A2/AD arena, the US must continue to improve its conventional kinetic capabilities. "The combination of long-range platforms and guided munitions not only provides an alternative to nuclear use but a capability that can be used for warfighting as opposed to deterrence."[16] Conventional innovations produced from the RMA, therefore, could potentially challenge the recent rise in hybrid warfare. Instant, precise, penetrating strikes against emerging targets of interest can deny adversaries their means to conduct asymmetric warfare without requiring the US to employ its large conventional forces. The effect of globalization on the strategic environment necessitates continuously improved conventional capability that can provide effective deterrence and kinetic effects despite an escalation in A2/AD environments.

## Global Power Distribution

Globalization not only affects the character of warfare, but it also alters the strategic environment as state and non-state actors vie to increase their power and international prominence. The conversion from a bipolar Cold War setting to today's unipolar environment opened power

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[16] Barry D. Watts, *Long-Range Strike: Imperatives, Urgency, and Options,* Center for Strategic Budgetary Assessments (Washington D.C.: CSBA, 2005), 37-38.

vacuums for weaker states and non-state actors to exploit.[17] For instance, the NSS depicts Asian and Middle Eastern regional strategies in which the US must monitor potential adversarial military modernization programs.[18] Consequently, the US must maintain its own modernization programs, with an emphasis on advanced long-range strike capability. Innovations in prompt global strike platforms provide conventional regional deterrence.[19] These capabilities will aid the US to promote peace, security, and prosperity for itself and its allies while reducing tension in these regions.

US contributions to extended deterrence further support NATO and UN peacekeeping strategies. The future strategic environment may demonstrate a world of "eight or more nuclear armed states—some of which are unstable, have ties to radical non-state groups, or both—with the prospect of more to follow."[20] Should nuclear weapons proliferate to another Middle Eastern state, other nations in that region will seek their own nuclear arsenals to protect themselves and stabilize the ensuing power redistribution.[21] History has shown the US nuclear deterrent umbrella stabilized regions for itself as well as its allies during the Cold War.[22] The changing strategic environment necessitates a similar deterrent umbrella as smaller states vie for greater power and legitimacy. Long-range conventional strike capability, unhindered by emerging A2/AD environments, can provide the deterrence required to control nuclear and other WMD proliferation.

Medium-range offensive and defensive systems have similarly destabilized US dominance in the Pacific theater. China has not only

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[17] Directorate of Strategic Planning, *Strategic Environmental Assessment,* 3-4, 11-12.
[18] Kugler, *U.S. National Security Strategy*, 11.
[19] Kugler, *U.S. National Security Strategy*, 75.
[20] Andrew F. Krepinevich, *US Nuclear Force: Meeting the Challenge of a Proliferated World*, Center for Strategic Budgetary Assessments (Washington D.C.: CSBA, 2009), xlv.
[21] Kathleen J. McInnis, "Extended Deterrence: The US Credibility Gap in the Middle East," *The Washington Quarterly,* Summer 2005, 169-186.
[22] T. V. Paul, Patrick M. Morgan, and James J. Wirtz, eds., *Complex Deterrence: Strategy in the Global Age* (Chicago: University Of Chicago Press, 2009), 136.

purchased advanced air defense systems from Russia, but China has also produced its own indigenous ballistic missile capability.[23] Should a conflict arise, China can threaten forward US bases and the Navy's freedom to maneuver throughout the theater.[24] The current US operational calculus in the Pacific must transform to developing threats. The US can maintain its fundamental strategy to project its power across the globe and ensure its national interests, but the US will be required to invest further in the RMA.[25] Investments in new long-range strike technologies, like the B-2 in the 1980s and 1990s, can prove costly. Yet, the investment proves its worth over time as it delivers substantial warfighting capability, provides deterrent value, and forces adversaries to expend their own resources to develop new and costly defensive capabilities.

Finally, nuclear proliferation also changes the strategic landscape between nuclear-capable countries. During the Cold War, nuclear escalation with a near-peer justified the US triad. Massive yet flexible retaliatory power offered US leadership various options to deal with escalation within a "delicate balance of terror."[26] Today, multiple states possess their own nuclear stockpiles. In this environment, the US finds the intentions and capabilities of regional nuclear adversaries more complex and difficult to decipher than those of the Soviet Union during the Cold War. Strategic signaling by arming long-range bombers with nuclear weapons no longer provides the deterrence it once did against the Soviet Union. While arguments exist for both maintaining and reducing the nuclear triad, the Mitchell Institute delivered a strong case

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[23] Watts, *Long-Range Strike,* 40-41.
[24] Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China* 2011 (Department of Defense, 2011), 31.
[25] Office of the Secretary of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Department of Defense, January 2012), 5.
[26] Quoted in Dr. Dana J. Johnson, Dr. Christopher J. Bowie, and Dr. Robert P. Haffa, *Triad, Dyad, Monad? Shaping the U.S. Nuclear Force for the Future* (Arlington, VA: Mitchell Institute for Airpower Studies, Dec 2009), 3.

for rethinking the relevance of the full triad in the new strategic environment.[27] The larger nuclear powers are reducing their stockpiles, and the utility of using a stealth bomber in a signaling role defies logic.[28] Surprise remains a fundamental characteristic of stealth attack. According to the Mitchell Institute's analysis of future global power distribution, reinvigorating a missile and submarine dyad along with new conventional long-range strike aircraft provides a better investment and deterrent capability than maintaining a large fleet of aircraft with a strategic nuclear role. Accordingly, conventional and nuclear weapon innovation and proliferation play a major role in the power distribution among state and non-state actors in the emerging strategic environment.

**Rise of Non-State Actors**

The final characteristic of globalization relevant to long-range strike capability emphasizes the rise of non-state actors. Similar to the redistribution of power evident between states, the unipolar strategic environment also exhibits non-state actors vying for power to achieve their own political agendas. In order to compete against asymmetric military powers, the "proliferation of sophisticated weapons and technology . . . extend[s] to non-state actors as well."[29] The RMA initially provided the US and its allies distinct advantages by holding most global targets at risk. However, non-state actors have similarly exploited the technological benefits of the RMA. They have developed irregular attack capabilities that limit asymmetric force-on-force engagements and enhance their own precision strike capabilities.[30] Non-state actors are

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[27] Dr. Dana J. Johnson, Dr. Christopher J. Bowie, and Dr. Robert P. Haffa, *Triad, Dyad, Monad? Shaping the U.S. Nuclear Force for the Future* (Arlington, VA: Mitchell Institute for Airpower Studies, Dec 2009), 27-28.
[28] Amy F. Wolf, *The New START Treaty: Central Limits and Key Provisions* (Congressional Research Service, Apr 2011), 2-6.
[29] Office of the Secretary of Defense, *Sustaining U.S. Global Leadership*, 5.
[30]Barry D. Watts, *The Maturing Revolution in Military Affairs,* Center for Strategic Budgetary Assessments (Washington D.C.: CSBA, 2008), 40.

also relying more on mobility to enhance the survivability of their weapons and assets.[31] The lethality of "relatively inexpensive guided weaponry" now proliferated to non-state actors requires US vigilance to counter these threats to local, regional, and even global stabilization.[32]

The surprise terrorist attack against the US in 2001 by a non-state actor demonstrates the US will not easily discern the origin or nature of its next adversary.[33] While the military typically prepares its forces to defeat the capabilities of its nearest military peer, adversaries with inferior military means readily start conflict to achieve their objectives, thereby increasing the complexity of the security environment. Deterrence strategies against non-state actors become increasingly problematic because they lack valuable, tangible assets that the US can target or hold at risk.[34] Attempting to deter these groups, in the form of traditional conventional or nuclear kinetic capability, can actually become self-defeating.[35] After initiating conflict, the weaker non-state actor stands to gain whether the stronger state chooses violent retaliation or conciliation. Choosing a violent response becomes costly because of the difficulty in employing large military force against an ill-defined adversary that does not share the same values or paradigm of warfare. The non-state actor can attack at will because provoking the larger state can force it to exhaust its own resources and eventually undermine its legitimacy. Conversely, military restraint after a provocation demonstrates weakness on the part of the larger military power. In this sense, the stronger military state faces a lose-lose situation whereby deterrence may not succeed.

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[31] Perry et al., *Long Range Bombers*, 13.
[32] Watts, *Revolution in Military Affairs*, 11.
[33] Williamson Murray, ed., *The Emerging Strategic Environment: Challenges of the Twenty-First Century* (Westport, Conn.: Praeger, 1999), xiv.
[34] Emanuel Adler, "Complex Deterrence in the Asymmetric-Warfare Era," in *Complex Deterrence: Strategy in the Global Age*, T. V. Paul, Patrick M. Morgan, and James J. Wirtz, eds. (Chicago: University Of Chicago Press, 2009), 85.
[35] Emanuel Adler, "Complex Deterrence," 86.

The lingering compellent strategy used by the US and the coalition forces against terrorist groups over the last decade prove the complexity of combating non-state actors. Compellence and the retaliatory option of deterrence against non-state actors have become difficult to enforce in the current strategic environment and indicate the future shall demonstrate similar trends. Traditional fielded forces may not completely eradicate these threats even after prolonged conflict due to the difficulty in finding valuable targets essential to the success of the non-state actor. Continued development of long-range strike capability, however, demonstrates potential at least against the militaristic aspects of these adversaries. Like state actors, for instance, terrorist groups still maintain training camps, possess limited means to wage war, and seek the proliferation of WMD and nuclear weapons. The US, at a minimum, can deny these assets through quick, precise, long-range strikes. Modern long-range strike capability, therefore, will continue to offer alternatives that challenge non-state actors without engaging in lengthy, irregular conflicts with asymmetric forces.



## Conclusion

The fundamental role of airpower in the strategic environment over the next 20 years will not look drastically different from today. Access and stability across the air domain shall remain vital to national security.[36] However, globalization of the technological innovations in military weapons and information networks brought about by the recent RMA increase the threats against US airpower. Despite these increasing threats, freedom to maneuver in the air domain shall remain a principal US military strategy against state and non-state actors alike.[37]

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[36]John A. Shaud, *Air Force Strategy Study: 2020-2030*, Air Force Research Institute (Maxwell AFB, AL: Air University Press, Jan 2011), 8.
[37] Shaud, *Air Force Strategy Study*, 27.

Globalization has also accounted for significant power redistributions and the rise of non-state actors. Against both state and non-state systems, the US must maintain counter-proliferation strategies for nuclear weapons and other WMD. The US must also counter attempts to develop asymmetric advantages that negate the capabilities of US airpower. Adversaries will continue to harden valuable targets, disperse and mobilize weapons, collocate military assets with civilians, improve air defenses, increase cruise missile ranges to threaten forward US bases and naval access, and develop measures that reduce US airpower capability in the future.[38] Because of these increasing threats against current US air dominance, the future strategic environment may prove problematic for a single long-range platform to maintain autonomous strike capability. Consequently, the future of long-range strike systems will require continued innovation in the areas of networking and integration with other assets. These features of globalization and the RMA within the future strategic environment promise to change the characteristics, but not the nature, of warfare.[39] The next chapter will demonstrate how a new long-range strike aircraft, by maintaining and evolving certain enduring functional characteristics, will continue to provide substantial capability in this environment.

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[38] Barry D. Watts, "American Air Power," in *The Emerging Strategic Environment: Challenges of the Twenty-First Century,* Williamson Murray, ed. (Westport, Conn.: Praeger, 1999), 197, 212.

[39] Williamson Murray, ed., *The Emerging Strategic Environment*, xiv.

# Chapter 5
# Future Bomber Attributes

As described in the three case studies above, long-range strike platforms have maintained several core functional characteristics. Certain individual attributes, like economy of force, surfaced as technological innovations responded to the changing strategic environment. These characteristics provided the fundamental value each weapon system contributed to national defense both as the means to deliver kinetic effects against the country's adversaries and as tangible tools for deterrence. The USAF has incorporated long-range heavy bombers as principal members of its arsenal for over seven decades. Since the inception of the B-17, the world's strategic context has evolved, and the bomber's aperture of functional contributions to national defense has opened in response to new strategic landscapes. Long-range strike platforms have evolved insomuch as technology enhanced both their effectiveness and efficiency. Despite current military downsizing and the expectation of a peaceful period following the major combat operations in Iraq and Afghanistan, the benefits of investing in a new long-range strike platform now outweigh the costs. This chapter synthesizes the enduring functional characteristics of long-range strike aircraft with the emerging strategic environment and deciphers the relevance of a new heavy bomber and its role in the future USAF.

## USAF Heavy Bomber Justification

Among four major factors (technological, economic, bureaucratic, and strategic) that influence the development of a new heavy bomber program, history proves the contemporary strategic environment

primarily affects the decision-making process.[1] The strategic environment directly affects how acquisition decision makers balance the other three factors as they develop requirements, commit resources, and vie for program support. In fact, "strategic objectives, operationalized through doctrine, played a more important role in the choice of bombers than did any other factor."[2] The Army Air Forces (AAF) needed the B-17 to take the fight past the Axis front and threaten German cities during World War II. Strategic Air Command (SAC) required nuclear laden B-52s to reach Soviet targets during the Cold War. The USAF likewise sought a highly survivable platform in the B-2 that could threaten the sanctuary of highly defended targets into the twenty-first century. Managers of airpower force structure developed these three weapon systems in response to their respective strategic environments.

Major weapon systems take years to research, develop, and produce, but the resulting platform dominates its arena for only a finite period. Technological innovations to preserve as well as deny access in the air domain never cease, and adversaries adjust their military capabilities to counter the USAF's new asymmetric advantages. "Some current global trends include proliferation of fifth-generation aircraft; more . . . surface-to-air . . . missiles and weapons; surface- and air-based directed energy weapons (DEW); . . . offensive and defensive cyber capabilities that could influence the effectiveness of . . . operational command and control, suppression of enemy air defenses, and other electronic warfare capabilities; and the increasing use of remotely piloted aircraft (RPA) in expanding mission areas."[3] The cycle continues as the current bomber force ages and their capabilities against emerging air defenses decrease. In order to justify the acquisition of a new bomber,

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[1] Michael E. Brown, *Flying Blind: The Politics of the U.S. Strategic Bomber Program* (Ithaca: Cornell University Press, 1992), 305.
[2] David S. Sorenson, *The Politics of Strategic Aircraft Modernization* (New York: Praeger, 1995), 214-215.
[3] John A. Shaud, *Air Force Strategy Study: 2020-2030,* Air Force Research Institute (Maxwell AFB, AL: Air University Press, Jan 2011), 8.

the USAF must make a case to show a perpetual requirement for a long-range penetrating platform continues to exist in the evolving strategic environment.[4]

The strategic justification for a new long-range strike system must therefore revisit the penetrating bomber versus standoff weapon argument. Lessons learned from a similar decision process during the Carter administration show the USAF should not pursue only one system or the other. Both approaches provide distinct capability and enhance each other because their combination provides flexibility to the combatant commander. Standoff weapons theoretically enable the USAF to attack targets from distances outside the ranges of air and naval defense threats. However, as adversarial defenses continue to improve, they will push the sanctuaries enjoyed by current standoff platforms further away and will consequently require further innovation and range from the weapon itself. Like its predecessors, the USAF may also have to relegate the B-2 to a standoff role in the near future.[5] Unfortunately, the production of an effective standoff weapon has historically resulted in costs exceeding two orders of magnitude over a smart gravity bomb.[6] Cruise missiles also do not offer the same capability against hardened targets compared to gravity weapons. Cruise missiles trade the weight required for hardened casings and penetrating nose cones for engines and propellant that increase their range. Penetrating bombers, although expensive to produce and maintain, also offer the USAF a reusable platform and more flexibility in targeting. The military would have to purchase an extraordinary stockpile of costly standoff weapons to sustain a prolonged war against a state-of-the-art Integrated Air Defense

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[4] Brown, *Flying Blind*, 317.
[5] Frank P. Donnini, *Battling For Bombers: the U.S. Air Force Fights For Its Modern Strategic Aircraft Programs* (Ithaca: Praeger, 2000), 114.
[6] Barry D. Watts, "American Air Power," in *The Emerging Strategic Environment: Challenges of the Twenty-First Century,* Williamson Murray, ed. (Westport, Conn.: Praeger, 1999), 205-209.

System (IADS). Finally, a penetrating platform offers substantially shorter target-to-engagement times for emerging threats.[7] Loitering bombers can offer kinetic effects within minutes versus the lengthy programming and fly-out times of standoff weapons.[8] Innovations in both approaches, however, will once again prove the prudent choice. Standoff weapons decrease risk to aircraft and their crews in certain situations, but a new penetrating bomber, capable of slipping past advanced air defense systems, will provide the greatest flexibility for combatant commanders against heavily defended and hardened targets.

Operations Desert Storm, Allied Force, Enduring Freedom, Iraqi Freedom, and Odyssey Dawn have proved the long-range bomber is no longer just a "Cold War weapon in a post-Cold War world."[9] During the opening nights of each of these conflicts, long-range strike platforms penetrated air defenses and delivered gravity weapons against critical targets. Penetrating bombers offer more value today than during the Soviet era due to their ability to leverage advanced technologies against targets located virtually anywhere in the world. They can also deliver relatively swift kinetic effects against small target sets without requiring large supporting packages or theater military buildup. New combat capabilities from the revolution in military affairs (RMA) place fewer US personnel at risk while countering the increasing militarization of disaffected state and non-state actors. These adversaries have not ceased their pursuits to proliferate nuclear and other weapons of mass destruction (WMD), and they continue to limit the US its ability to employ forward-based tactical airpower. Long-range strike aircraft

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[7] Known as the Find-Fix-Target-Track-Engage-Assess (F2T2EA) loop, bombers have historically offered more flexibility to engage pop-up targets quickly than standoff weapons. Unmanned cruise missiles require lengthy flight programing and deconfliction plans compared to manned, or man-in-the-loop, weapon systems that can loiter and maneuver over the battlespace in real time.

[8] Barry D. Watts, *Long-Range Strike: Imperatives, Urgency, and Options,* Center for Strategic Budgetary Assessments (Washington D.C.: CSBA, 2005), 70-74.

[9] Charles M. Perry et al., *Long-Range Bombers & the Role of Airpower in the New Century* (New York: Inst for Foreign Policy Analysis, 1995), 28-29.

continue to provide a logical response to these threats. Therefore, similar to past strategic environments, the strategic justification of a new heavy bomber for the defense force structure remains the primary deciding factor for procuring the next long-range strike platform.[10]

**Future Functional Characteristics**

Penetrating bombers have provided functional characteristics that will continue to apply in the future strategic environment; defined above by globalization, global power distribution, and the rise of non-state actors. Unlike the past, however, the USAF has allowed a "bomber gap" to develop.[11] The USAF has relied on the current bomber fleet for over two decades to sustain these functional characteristics without considering a replacement airframe for its aging platforms. Directing resources toward sustainment programs has helped the fleet project structural viability through 2040 for both the B-52 and B-1 and 2058 for the B-2.[12] However, structural viability does not equal combat effectiveness. By as early as 2020, fifth-generation adversarial aircraft may render even the B-2 unable to penetrate critical target areas.[13] Such threats will demonstrate a stark contrast to the relatively benign environments the USAF faced in Afghanistan, Iraq, and Libya. Recent guidance and dedicated funding, however, show the USAF has placed a high priority on producing a new bomber by the early 2020s.[14]

The USAF will continue to benefit in the future strategic environment from a platform able to provide *range, persistence, penetrant strike, flexibility, multi-payload, precision, deterrence*, and *economy of*

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[10] Frank P. Donnini, *Battling For Bombers: the U.S. Air Force Fights For Its Modern Strategic Aircraft Programs* (Ithaca: Praeger, 2000), 147-148.
[11] Rebecca Grant, *Return of the Bomber: The Future of Long-Range Strike,* Air Force Association Special Report (Arlington, VA: Air Force Association, February 2007), 8-11.
[12] John A. Tirpak, "Time to Get Started," *Air Force Magazine*, December 2012, 31.
[13] Grant, *Return of the Bomber*, 20.
[14] Office of the Secretary of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Department of Defense, January 2012), 5.

*force*. Emerging state and non-state threats to US national interests in the Middle East and potentially in the Pacific theater illustrate the next platform must be able to attack targets from ranges further than expected from today's bomber fleet. This future strategic environment will continue to threaten the USAF's reliance on forward basing. New long-range strike capability will become necessary to maintain an asymmetric attack advantage and deterrent value. History has also proven neutral countries can increase distances to target areas by denying over-fly rights. The USAF may further choose not to request these rights in order to maintain an element of surprise. By developing a new long-range, stealthy bomber, the USAF can maintain longer loiter times with large payloads than other strike options.[15] Advanced air defenses will deny sanctuary to the USAF's non-stealthy air refueling platforms and will result in unreachable target sets or shortened loiter times from the current bomber fleet. In addition, innovations in fuel efficiency as well as the effects from smaller weapons could decrease the large payload weights of the current bomber fleet by half while producing the same effects and target coverage.[16] Capitalizing upon these technologies could increase the range and loiter time of the aircraft due to decreased payload and fuel weights.

While the B-2 has demonstrated the benefits of efficient fuel consumption compared to older platforms, the B-2 program taught the USAF the importance of persistence. In order to sustain or deter a prolonged future conflict in a region where the adversary threatens US forward basing and carrier-based airpower, the USAF must invest in and maintain a substantially larger penetrating bomber fleet. In some instances, even stealthy short-range attack aircraft could prove inadequate against newer threats because of insufficient range and lack

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[15] Congress of the United States Congressional Budget Office, *Alternatives for Long-Range Ground-Attack Systems* (Washington D.C.: U.S. Government Printing Office, March 2006) 31-32.
[16] Watts, *Long-Range Strike*, 68-70.

of safe havens to conduct air refueling.[17] These threats could force the USAF to rely more heavily on long-range penetrating platforms to attack targets with precision weapons. Dynamic air attack roles often conducted by other platforms will require precise time-sensitive targeting (TST) and close air support (CAS) capability from a new long-range aircraft when rules of engagement minimize or render collateral damage unacceptable.[18] Furthermore, emerging threats in the dynamic strategic environment of the future will require a platform capable of penetrating advanced defenses, delivering multiple types of precision weapons of varying effect, and offering flexible attack options within that dynamic battlespace. Each of these characteristics will become vital capabilities as adversaries continue to exploit older US technologies. A new bomber fleet of persistent size and strength, capable of reinvigorating these attributes in the future air domain, will once again provide an asymmetric advantage for the USAF. More importantly, it will also provide a substantial deterrent value against state and non-state actors alike.

While each of the bombers studied in the cases above provided deterrent value within their respective strategic environments, the last attribute regarding economy of force appeared in conjunction with the advent of stealth technology. Since World War II, the USAF did not reconsider its concept of force packaging until stealth aircraft carrying precision weapons substantially decreased the requirement for support assets.[19] Prior to stealth and smart gravity weapons, the ratio of smaller fighter and attack aircraft to heavy bombers in the USAF inventory increased by a factor of five from 1950 to 1995.[20] The RMA has already demonstrated a reverse in this trend as the USAF decided to produce a

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[17] Clark A. Murdock, *U.S. Air Force Bomber Modernization Plans: An Independent Assessment,* Center for Strategic and International Studies (Jan 2008), 11, 17.
[18] Murdock, *U.S. Air Force Bomber Modernization Plans,* 12.
[19] Watts, "American Air Power," 198-204.
[20] Watts, "American Air Power," 187.

relatively small number of F-22s to replace its aging fleet of fighter aircraft. Furthermore, the final F-35 purchase remains questionable. Like the B-2 procurement program, these aircraft demonstrate large technological leaps that result in smaller aircraft purchases than initially projected. Consequently, in order to preserve its airpower dominance at sustainable costs, the USAF has come to rely on superior technology over large numbers of airframes. The USAF will assuredly continue this trend with its new long-range strike program, but a prudent acquisition strategy will accept proven, off-the-shelf technologies to limit a rapid escalation in production costs. Because of the F-22 and F-35 programs, the current technological readiness levels of several stealth, avionics, communications, systems, and manufacturing technologies rank substantially higher today than when Northrop Grumman and Lockheed pioneered these areas in the early 1980s.[21] By capitalizing on the technological readiness of these innovations in the military aircraft industry, the USAF will acquire a long-range strike platform that offers a substantial economy of force. In response to the future strategic environment, the new platform will be able to cover a large number of targets, minimize risk to aircrew and assets, and maintain affordable production costs that ultimately allow for a fleet large enough to affect true persistence across a battlespace.

Finally, in addition to the eight historic functional characteristics, a new long-range strike aircraft will also require *integration*. As early as 2006, the USAF defined the capabilities required of future long-range strike systems as responsive, flexible, survivable, and situationally aware.[22] Maintaining situation awareness, defined as "the ability to use onboard sensors plus connectivity to external information sources to improve combat effectiveness," will require greater integration with other

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[21] Rebecca Grant, *Technology Readiness for a New Long-Range Bomber,* IRIS Independent Research (Arlington, VA: Lexington Institute, September 2008), 15-20.
[22] Congressional Budget Office, *Long-Range Ground-Attack Systems,* 6.

systems in the future. For instance, B-2 designers minimized its emissions to help increase its stealth characteristics, thereby limiting its connectivity with other platforms. Furthermore, the B-2 did not have a supportive stealth fighter capable of defensive counter-air (DCA) within contested airspace until the USAF declared full operational capability (FOC) for the F-22 in 2007. This potentially constrained the USAF to employ the B-2 against targets only under the cover of darkness.[23] The next bomber must integrate with other platforms in manners that increase its persistence and ability to attack targets at any time. The next bomber will require innovations in communications emissions to ensure connectivity with advanced US and coalition networks while denying traceability of those emissions by its adversaries.[24] Improved communications capability and data-link integration will only enhance its flexibility, defensibility, and ability to attack emerging targets in a highly defended yet dynamic strategic environment.



## Conclusion

Globalization in the future strategic environment will heavily influence the development of future military acquisition programs. The US will face multiple state and non-state adversaries that will rely on innovative and dynamic ways to exploit older strike capabilities with advanced kinetic defenses and target protection schemes. While the case studies above demonstrate the remarkable accomplishments of USAF bombers, adversaries are threatening the current fleet's ability to reach and affect targets in the near future. Consequently, the USAF must develop a new aircraft to espouse the nine functional characteristics of long-range strike aircraft developed in this study. The features of the future strategic environment will require this new aircraft to possess the seven core functional characteristics bombers have provided the USAF

[23] Watts, *Long-Range Strike*, 12, 57.
[24] Grant, *Technology Readiness*, 8-10.

for decades: *range*, *persistence*, *penetrant strike*, *flexibility*, *multi-payload*, *precision*, and *deterrence*. It must also exhibit the *economy of force* and *integration* functional characteristics that depend upon further technological innovation from the RMA. Taken together, these nine functional characteristics, enhanced by current advances in military technology, will produce yet another asymmetric advantage for the USAF in the air domain. Developed and produced over the next decade, a new long-range strike aircraft will prove vital as a deterrent and kinetic enabler against the dynamic adversaries expected in the future.

# Conclusion

Since their service began in World War II, long-range bombers have increased their value based upon the functionality they have provided to support US defense strategy. The USAF has developed and employed several iterations of long-range strike aircraft in response to evolutions in the strategic environment. Increased bomber involvement in combat operations over the last two decades demonstrates their importance to civil leadership and combatant commanders across the globe. Recent US interest in a new long-range strike bomber (LRS-B) further demonstrates the vital role bombers continue to have in projecting US airpower.

The 2006 Quadrennial Defense Review (QDR) charged the USAF to field a new LRS platform by 2018.[1] The 2010 QDR continued to emphasize the importance of LRS research, development, and funding; however, it did not dictate a platform delivery date.[2] Proponents of long-range bombers have published many analyses in response to the two QDRs describing the types of technologies required to enhance the next LRS-B and make it a viable weapon delivery platform for the future. Opponents of strategic bombers have questioned the utility of these expensive platforms when the Department of Defense (DOD) could pursue other promising, possibly cheaper capabilities to fill the upcoming bomber gap. The functional analysis provided here, in contrast to already published capabilities analyses, establishes baseline requirements and characteristics for the future LRS system. This thesis also concludes the USAF would make a prudent investment by developing a new LRS-B system now to confront the future strategic environment. As the US continues its efforts to constrain its budgets,

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[1] Office of the Secretary of Defense, *Quadrennial Defense Review Report* (Department of Defense, January 2012), 49.

[2] Richard Kugler, *New Directions in U.S. National Security Strategy, Defense Plans, and Diplomacy: A Review of Official Strategic Documents* (Washington, D.C.: National Defense University Press, 2011), 19.

these issues will become increasingly relevant to policy makers and airpower strategists.

The LRS production discrepancy between the 2006 and 2010 QDRs resulted from a cancelled next generation bomber (NGB) program. The NGB began in concept to supplement the long-range bomber fleet with a more medium-range stealthy platform similar to the B-2. The 2018 production deadline became unrealistic because the bomber industrial base had deteriorated since the termination of the B-2 production line.[3] The DOD and USAF initial funding estimates for this program, therefore, displayed early similarities to the costly B-2 acquisition process.[4] The NGB program sought highly advanced fifth-generation stealth capabilities in a relatively short developmental phase without considering current technological readiness levels and integration with other platforms. Despite the cancellation of a NGB by 2018, Congress continued to appropriate funds in the 2010 budget for research and development of a LRS-B. The LRS-B will focus on "using a streamlined acquisition process with an open architecture approach and off-the-shelf technologies, while employing current gravity and other air-delivered weapons . . ."[5] The USAF can achieve, therefore, an affordable system by capitalizing upon existing technologies already offered by the F-22 and F-35 programs and integrating with the fifth-generation family of strike systems.

## LRS-B Functional Characteristics

This thesis describes the distinct environments surrounding the development and employment of three long-range bombers throughout USAF history. By analyzing how each bomber functioned within its

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[3] Jeremiah Gertler, Air Force Next-Generation Bomber: Background and Issues for Congress (Congressional Research Service, Dec 2009), 20-23.
[4] Gertler, *Air Force Next-Generation Bomber*, 24-28.
[5] Lt Gen James Kowalski, "New Penetrating Bomber" (speech, Long Range Strike Caucus, Washington D.C., 17 Apr 2011).

respective environments and defining how the future strategic environment compares to those of the past, this thesis induces the functional characteristics required from a new LRS-B. The B-17, B-52, and B-2 historical analyses provide seven prevalent characteristics of heavy bombers. Two additional characteristics depend upon further innovations in military technology. All combined, Table 4 summarizes the nine functional characteristics vital for a prudent and relevant LRS-B investment.

**Table 4: Proposed LRS-B Functional Characteristics**

| Functional Characteristic | B-17 | B-52 | B-2 | LRS-B |
|---|---|---|---|---|
| Range | X | X | X | Global-strike capable within hours |
| Persistence | X | X | | Fleet size sustains major combat ops |
| Penetrant Strike | X | X | X | Loiter in dynamic & contested airspace |
| Flexibility | X | X | X | Deliver versatile/dynamic strike options |
| Multi-Payload | | X | X | Employ vast range of kinetic weapons |
| Precision | | X | X | Minimize collateral damage |
| Deterrence | | X | X | Credible kinetic strike capability |
| Economy of Force | | | X | Minimize risk and resources |
| Integration | | | | Data-linked with other platforms |

*Source: Author's Original Work*

Table 4 shows the B-17 offered *range*, *persistence*, *penetrant strike*, and *flexibility* during World War II, and these characteristics have remained fundamental to every bomber developed thereafter. On 7 December 1941, "the American polity . . . recognize[d] . . . a world where technology was shrinking distances while increasing the lethality and range of weapons."[6] Today's bombers can literally reach targets anywhere in the world through air refueling. Persistence has ebbed and flowed depending on fleet size and bombers' ability to loiter in contested airspace. Penetrant strike remains a distinguishing characteristic of

[6] Williamson Murray, ed., *The Emerging Strategic Environment: Challenges of the Twenty-First Century* (Westport, Conn.: Praeger, 1999), xiv.

bombers over other strike systems that typically take longer to engage targets, yield limited effects against certain types of targets, and cost significantly more per weapon. Finally, all bombers have demonstrated a high degree of flexibility by fulfilling multiple roles or maintaining a degree of upgradability that responds to an evolving strategic environment with innovations to the parent platform.

History also demonstrated increased bomber functionality in response to the evolving landscape. The B-52 added *multi-payload*, *precision*, and *deterrence* throughout the Cold War and still provides these characteristics today. Today's triad of USAF bombers offers a myriad of weapon capability across the battlespace, to include cruise missiles, cluster munitions, mines, large penetrating conventional bombs, and nuclear weapons. Many of those weapons minimize collateral damage via precision guidance systems in the form of GPS-aided or laser-guided targeting. Finally, the nuclear and conventional capability of today's bomber fleet deters US adversaries and provides a stabilizing tool to help maintain US interests abroad.

In addition to the seven characteristics described above, the revolution in military affairs (RMA) has and will continue to enable two additional functional attributes in response to the evolving strategic landscape. Technological innovations in precision weapons, large multi-payloads, and autonomous penetrant strike capability enable the B-2 to demonstrate an *economy of force* against dynamic and well-defended adversaries.[7] The B-2 can attack multiple primary targets with precision weapons on a single mission rather than employing a formation of bombers against a single target. It therefore minimizes "overkill" and risk to multiple platforms or aircrew by reducing the amount of resources required to achieve an objective. In addition, technology will become a vital enabler for the next LRS-B to exhibit *integration* with

[7] See note 32 on page 34.

other fifth-generation aircraft and networks. The concept of a strictly autonomous strike platform may prove cost prohibitive to counter all legacy and next-generation air defense threats.[8] However, future penetrant strike capability remains possible through close interoperability with other stealthy platforms and systems.

Because of the continued globalization of interstate activities and the influential rise of non-state actors in a global redistribution of power, a new LRS-B will provide more relevance to US defense strategy now than during the Cold War. Adversaries will continue to threaten US national interests and counter US military dominance by undermining its advantages rather than competing with equivalent force. They will take further measures to reduce legacy US airpower capability in the future by hardening valuable targets, dispersing and mobilizing weapons, collocating military assets with civilians, improving air defenses, and increasing cruise missile ranges to threaten forward US bases and naval assets. A new long-range bomber will challenge these increasing threats.

## Implications

Military and civilian leaders must ensure our military means reconcile with our strategic doctrine because doctrine and force capability have direct political ramifications. This study determined the characteristics of global strike platforms as instruments used to support doctrine and how they will remain vital to maintaining US interests in the future strategic environment. It concludes by offering two implications. First, the USAF should understand what functionality it would lose by failing to field a new LRS-B. Within the next decade, the *persistence, penetrant strike, deterrence*, and *economy of force* functional characteristics the current bomber fleet has relied upon for decades will atrophy against the efforts adversaries are taking to shape the strategic

[8] Lt Gen James Kowalski (Commander, Air Force Global Strike Command, Barksdale AFB, LA), interview by author, 15 February 2012.

environment. The fleet would further lack two-way *integration* with newer fifth-generation platforms without substantial upgrades. This study did not include a detailed analysis of the B-1 and the substantial long-range strike capability it provides. However, its contributions to the fleet would not retain the functionality for the USAF that would be lost without a new LRS-B. The loss of these five functional characteristics, summarized in Table 5, would force the US to rely on other unproven, and possibly less capable, means to support national defense and defend US interests abroad.

**Table 5: Future Functionality Lost Without LRS-B**

| Functional Characteristic | B-52 | B-2 | Description of Lost Functionality |
|---|---|---|---|
| Range | X | X | |
| ~~Persistence~~ | | | Fleet unable to sustains major combat ops |
| ~~Penetrant Strike~~ | | | Unable to loiter in dynamic/contested airspace |
| Flexibility | X | X | |
| Multi-Payload | X | X | |
| Precision | X | X | |
| ~~Deterrence~~ | | | Lose credible kinetic strike capability |
| ~~Economy of Force~~ | | | Risk and required resources increase |
| ~~Integration~~ | | | Platforms not data-linked with each other |

*Source: Author's Original Work*

Second, the USAF should develop a historically based functional analysis of short-range attack aircraft similar to this study. A comparison between future long- and short-range strike functionality, as opposed to capability, could better inform funding decisions in the context of a fiscally restrained military budget. The functional characteristics of long-range strike assets, developed throughout the history of bomber aircraft, should underpin the decisions to go forward with a new LRS-B. However, these same characteristics could temper preconceived notions about future short-range strike acquisition programs. While they are sure to offer additional functionality, short-

range strike platforms cannot offer all of the functional characteristics described above in Table 4. The future battlespace will require the nine functional characteristics defined in this study from the next bomber for the US to maintain an asymmetric advantage in its ability to project global power. How these characteristics rank and overlap with those offered by other types of strike platforms could prove useful as the USAF continues to move forward to support national defense policy.

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